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Trends in the application of

Steel Mill Electric Power Drives

with a discussion of present tendencies in solving problems of electrical distribution and conversion, and the use of electric heat

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PRACTICALLY every steel mill in this country, if not already equipped with electric rolling mill drives, is either engaged in electrifying one or more mills or is considering such work. Indicative of this, there were 146 main drive motors totaling 198,240 hp. purchased during the year's period between April 1, 1926 and April 1, 1927. These motors are listed in the table on page 246.

Of these 146 motors, 90,490 hp. are of the adjustable-speed, direct-current type, 52,700 hp. are of the constant-speed induction type, 17,450 hp. are of the synchronous type, 11,200 hp. are of the adjustable-speed, alternating-current type (such as Scherbius or Kraemer), and 40,600 hp. are of the reversing, direct-current type.

Probably the most marked tendency is the rapid electrification of steam-engine-driven mills. The most extensive electrification now under way, and probably the most extensive undertaken by a large steel company, is in progress in the plants of the Bethlehem Steel Co. During the past year this company has purchased 20 motors totaling 60,850 hp., which is nearly one-third of the total horsepower of main drive motors sold during this period.

Reports from the Colorado Fuel & Iron Co., which is completing the initial part of its electrification program, state that electrification of this steel plant has resulted in a great saving of fuel, maintenance, labor and operating costs. The saving in coal alone will amount to over 150,000 tons per year, which will be further increased with the completion of the electrification. Increased production has resulted from the installation of electric drive on the mills. Every mill electrified has exceeded all previous production records. The mill speeds remain the same as formerly, the increased production being due to a more uniform mill speed being maintained than was possible with the former steam engine drive.

Six days, three and one-quarter hours was the record time made last year for the replacement of an engine drive with a reversing motor drive on a 36-in. blooming mill at the Indiana Harbor plant of the Inland Steel Co. The engine was a 50-in. x 60-in. twin simple reversing engine and was replaced by a 7,000-hp., 70/150-r.p.m., single-unit reversing motor. The work involved the dismantling and removal of the old steam engine and piping, weighing about 400 tons; blasting and excavation of 225 cu.ft. of old concrete foundations; setting of forms; pouring of 120 cu.yd. of concrete for the new motor foundation, and the assembly, connection and testing of the reversing motor drive. The use of a quick-setting cement for the new foundations permitted the motor bedplate to be set within 11 hr. after the concrete had been placed in the forms.

It is well known that, while the increasing use of electric drives has been the chief factor in reducing rolling costs and increasing production, there have also been improvements in the design of the mills that are responsible for a share of the better rolling conditions. For this reason the replacement of many wasteful steam drives is delayed until it is felt that time and funds are available to install both a new mill and an electric drive at the same time. At the plant of the Phoenix Iron Co., however, the three electric drives have been installed without any changes to the mills. The 22-in. and 24-in. mill drives have been in operation 2½ yr. and the reversing motor at the 36-in. mill for several months. It is estimated that the power cost of these devices as compared with the former steam drives has been cut in half. This, together with other savings brought about by the elimination of all steam engines, will in three years cover the cost of the electrification. In the case of the blooming mill, it is shown that electrical equipment can be fitted to an existing

mill without handicapping in any way any future mill equipment that may be purchased.

Adjustable Speed Drives—At the present time, only about 25 per cent of all of the motors installed on steel mill main drives are direct-current machines. The remaining 75 per cent are almost entirely induction motors. The wide use of the induction motor for this service is explained by its reliability of operation, ability to use alternating-current power without conversion, high efficiency, freedom from commutation troubles, low first cost and low maintenance. Adjustable-speed control can readily be obtained by the addition of Kraemer or Scherbius regulating equipment, as evidenced by the 50 Kraemer and 70 Scherbius equipments now in successful operation in this country.

Nevertheless, during the past year the number of direct-current motors purchased for main roll service is more than double the number of alternating-current motors. As a matter of fact there were sold 91 adjustable-speed direct-current motors totaling 90,490 hp. The reason for this is largely due to the development and increasing use of the modern high-speed continuous bar and strip mill with individually-driven, closely-spaced stands. On these drives accuracy of speed adjustment and regulation, with ease and flexibility of control are paramount considerations and are characteristic of the direct-current motor installations.

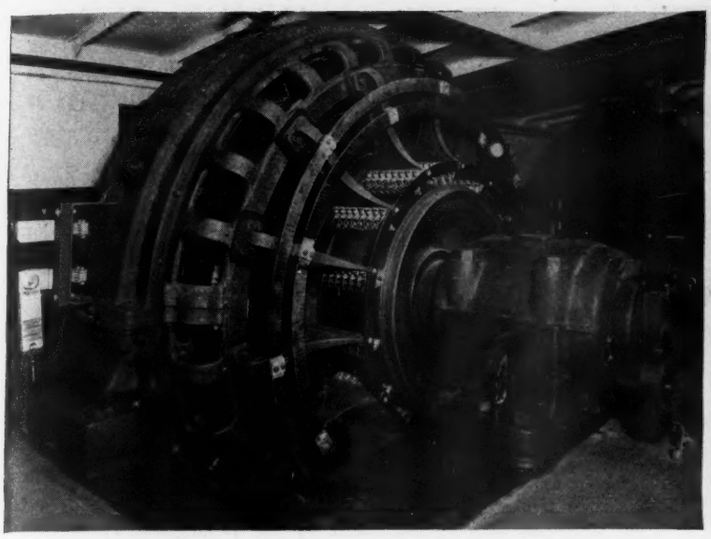
An interesting example of this relatively new type of mill with individually-driven stands, is the strip steel mill of the Columbia Steel Co. at Butler, Pa. The slabs are first rolled in a 27-in. reversing universal mill which is driven by a 5,000-hp. continuous-rated (12,500 hp. maximum), 70/150-r.p.m, 900-volt, d.c. reversing motor. After leaving the reversing mill the steel passes in succession through four stands of rolls, each of which is a four-high mill in which the working rolls are backed up by rolls of larger diameter. Each of the four stands is driven by a 2,000-hp., 200/400-r.p.m., 600-volt, direct-current motor. Power for these motors is obtained from three, 3-unit, synchronous motor-generator sets, each consisting of one 4,200-kva., 6,600-volt, synchronous motor and two 1,500-kw., 600-volt generators. The motor room for this mill is shown on page 248.

Among new installations indicating this trend toward individual

Motor-Driven Main Drives Purchased During Past Twelve Months

Company	Mill	Drive	Motors		Volts	Cycles	R.P.M.
			No.	Hp.			
Alan Wood Iron & Steel Co.	Jobbing Plate	Geared	1	1,200	2,200	25	500
	Jobbing Sheet	Geared	1	600	2,200	25	295
American Rolling Mill Co.	Sheet	Geared	1	1,200	2,200	25	244
	Bar	Geared	1	500	2,200	60	585
	Cold Roll	Geared	6	600	230	d.c.	400/800
American Sheet & Tin Plate Co.	16-in. strip mill	Geared	6	2,500	600	d.c.	160/320
	Sheet	Geared	1	2,000	2,200	60	300
	Steel Mill	.....	2	1,800	2,200	25	493
	Steel Mill	.....	1	350	2,200	25	485
	Cold Rolls	.....	1	750	2,200	25	245
American Steel & Wire Co.	18-in. Billet	.....	1	2,500	2,200	60	295
	10-in. Rod	Geared	1	3,000	600	d.c.	180/370
	10-in. Rod	Geared	2	800	600	d.c.	535/750
Babcock & Wilcox Co.	Seamless tube	Direct	2	300	230	d.c.	175/350
Bethlehem Steel Co.	12-in. Skelp	Geared	2	1,800	600	d.c.	275/550
	12-in. Skelp	Direct	1	1,100	600	d.c.	214/320
	12-in. Skelp	Direct	1	1,100	600	d.c.	246/382
	21-in. Skelp	Geared	1	6,700	6,600	25	500/250
	21-in. Skelp	Geared	1*	6,500	6,600	25	187
	21-in. Skelp	Geared	1*	4,000	6,600	25	83
	21-in. Skelp	Direct	1	2,600	600	d.c.	275/320
	152-in. Plate	Geared	1	4,500	2,200	60	450
	54-in. Blooming	Direct	1	7,000	750	d.c.	40/80
	42-in. Structural	Direct	2	7,000	750	d.c.	65/100
	42-in. Structural	Direct	2	1,500	750	d.c.	65/225
	Sheet	Geared	1	1,250	6,600	25	250
	Tin	Geared	2	1,250	6,000	25	250
	Tin Mill Cold Rolls	Geared	2	1,250	6,600	25	250
	10-in. Mill	.....	1	500	250	d.c.	375/750
Bourne Fuller Co.	34-in. Blooming	Direct	1	4,000	750	d.c.	58/140
	10-in. Merchant	Geared	3	300	230	d.c.	267/800
	10-in. Merchant	Direct	4	500	230	d.c.	267/800
	10-in. Merchant	Geared	1	500	230	d.c.	267/800
Central Alloy Steel Corp.	35-in. R. Blooming	.....	1	3,750	700	d.c.	50/130
Colorado Fuel & Iron Co.	25-in. Structural	Geared	1	3,000	6,600	60	450
	25-in. Structural	Geared	1	2,000	6,600	60	450
Columbia Steel Co.	18-in. Bar	Geared	1	1,500	2,200	60	322/193
Dilworth Porter Co.	10-in. Rod	Geared	1	500	2,200	60	600
Dirigold Corporation	20-in. Rolling	.....	1	300	440	60	440
Ford Motor Co.	10-in. Merchant	Geared	1	800	500	d.c.	200/600
	10-in. Merchant	Direct	1	2,000	500	d.c.	137/275
	10-in. Merchant	Direct	1	1,250	500	d.c.	300/550
	Roughing	.....	1	1,750	500	d.c.	100/200
	Finishing	.....	1	1,400	500	d.c.	450/550
Forged Steel Wheel Co.		.....	6	400	600	d.c.	500/1000
Gary Tube Co.	Steel	.....	1*	1,500	6,600	25	624
Illinois Steel Co.	10-in. Merchant	Geared	1	2,000	600	d.c.	315/500
	10-in. Merchant	Direct	2	700	600	d.c.	130/310
	10-in. Merchant	Direct	2	700	600	d.c.	210/660
	10-in. Merchant	Direct	1	500	600	d.c.	130/310
	10-in. Merchant	Direct	2	500	600	d.c.	150/550
	9-in. Merchant	Geared	1	1,000	600	d.c.	290/500
	9-in. Merchant	Direct	1	550	600	d.c.	336/588
	9-in. Merchant	Direct	2	550	600	d.c.	420/714
	9-in. Merchant	Geared	2	450	600	d.c.	211/422
	9-in. Merchant	Geared	4	400	600	d.c.	240/721
Inland Steel Co.	24-in. Sheet Bar	Geared	1	3,000	2,200	25	500/250
Jones & Laughlin Steel Corp.	Reversing Bar	Direct	1	3,000	650	d.c.	65/130
	Piercing	Geared	2	3,000	6,600	25	250
	Tube	Geared	1	1,500	6,600	25	375
	Tube	Geared	2	500	230	d.c.	400/800
Laclede Steel Co.	Tube	Geared	1	400	6,600	25	500
	10-in. Strip	Rope	1	1,500	600	d.c.	198/400
	10-in. Strip	Direct	1	600	600	d.c.	185/470
	10-in. Strip	Direct	1	600	600	d.c.	270/635
	10-in. Strip	Direct	1	720	600	d.c.	395/825
	10-in. Strip	Direct	1	720	600	d.c.	480/1000
Lukens Steel Co.	84-in. Tandem	Direct	1	1,200	330	d.c.	25/50
	84-in. Tandem	Direct	1	2,500	660	d.c.	53/80
Newton Steel Co.	Cold Roll	Geared	1	500	230	d.c.	400/800
Pacific Coast Steel Co.	22-in. Billet	Geared	1	2,400	2,200	60	505
South Chester Tube Co.	Tube	Geared	1	400	2,300	60	600
Standard Seamless Tube Co.	51-in. Piercing	Direct	1*	5,000	2,200	60	240
	Bar	Direct	1	2,150	535	d.c.	43/100
Suzuki & Co.	Sheet	Geared	1	1,200	2,200	60	240
	Cold Sheet	Geared	1	350	2,200	60	600
Timken Roller Bearing	Blooming	.....	1	1,500	2,200	60	355
Trumbull Steel Co.	Cold Strip	Geared	1	400	230	d.c.	400/800
	Edging Rolls	Geared	1	300	230	d.c.	400/800
Washburn Wire Co.	Rod Finishing	Direct	1	1,600	2,200	60	440
Weirton Steel Co.	16-in. Strip	Geared	3	2,500	600	d.c.	200/400
	16-in. Strip	Geared	2	2,000	600	d.c.	200/400
	16-in. Strip	Geared	1	1,500	6,600	60	200
	16-in. strip	Geared	2	1,500	6,600	d.c.	450
	Cold Roll Strip	.....	10	500	600	d.c.	400/500
West Leechburg Steel Co.	9-in. Strip	Geared	1	1,600	2,200	60	705
	9-in. Strip	Direct	1	800	2,200	60	505
Wheeling Steel Corp.	14-12-in. Skelp	Geared	3	2,000	600	d.c.	200/400
		Geared	1	500	600	d.c.	180/360
Youngstown Sheet & Tube Co.	Sheet	Geared	1	2,000	600	d.c.	230/460
	Seamless Tube	Geared	1*	450	2,200	60	720

* Indicates Synchronous Motor. This tabulation covers motor drives purchased between April 1, 1926 and April 1, 1927. For drives purchased prior to April 1, 1926, see page 250 of the June, 1926, issue of INDUSTRIAL ENGINEER.



More than 90,000 hp. capacity in motors of this type was purchased during the past twelve months.

These are adjustable-speed, direct-current motors used on hot strip, strip sheet, and bar mills. At the left is a Westinghouse 1,800-hp., 125/250-r.p.m. motor in the hot strip mill of the Acme Steel Co. At the right is one of the General Electric 2,000-hp. 200/400-r.p.m. motors in the strip sheet mill of the Columbia Steel Co.

drive, there should be mentioned the 13-stand mill that will be installed by the Illinois Steel Co. at its South Chicago plant, this mill being driven by 13 motors totaling 10,500 hp. At its Gary works a 15-stand mill will have 11 motors totaling 6,500 hp., all of which are of the direct-current, adjustable-speed type.

At the plant of the Weirton Steel Co. at Weirton, West Va., a new mill is to be installed that will be driven by three alternating-current and five direct-current motors, having a total continuous capacity of 16,000 hp.

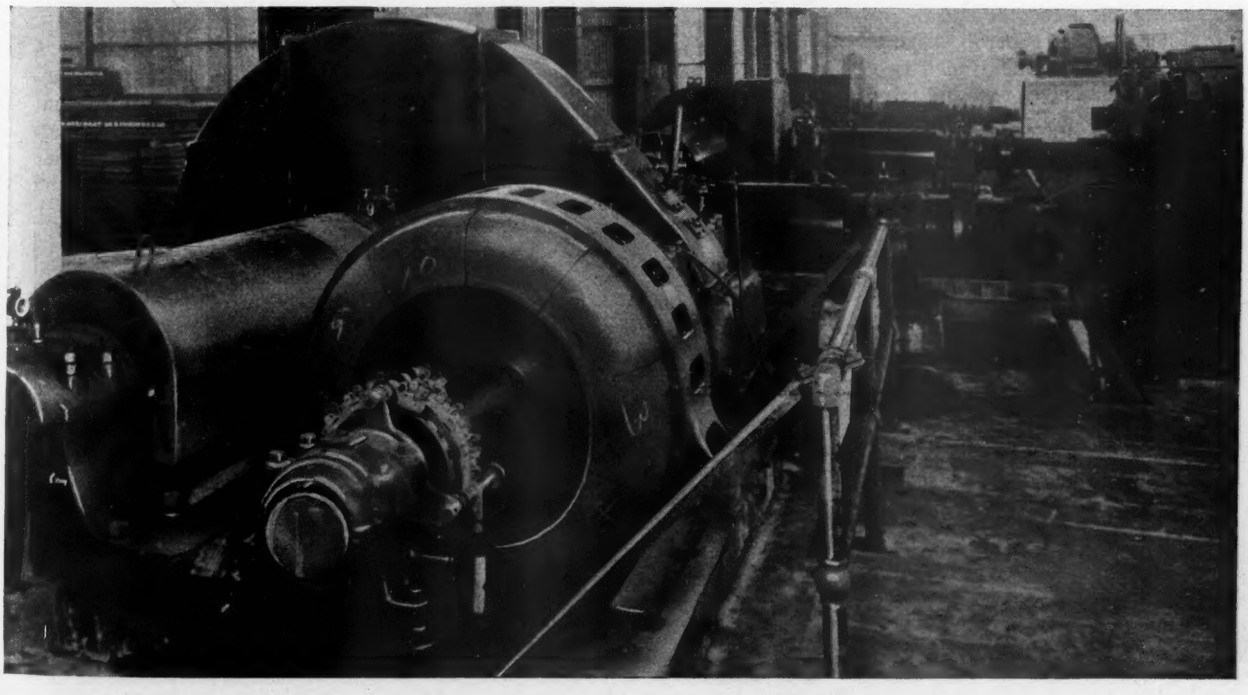
An improvement has been made in the control for tandem mill drives using separately-excited, compound-wound, direct-current motors. This consists of an adjustable rheostat in the separately excited series field which is mechanically connected to the operating mechanism of the main shunt-field rheostat so that the two rheostats are adjusted simultaneously. By the proper proportioning of resistance values the compounding excitation at all speeds may be made such that the speed change under load is less than 1½ per cent of the operating speed. The first installation using this system is said to be operating satisfactorily and several other equipments are on order.

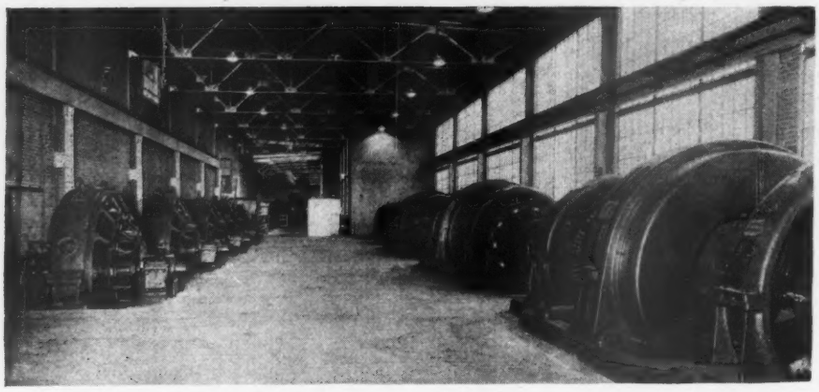
Notwithstanding the markedly increased use of direct-current, adjustable-speed, drives there is still a large demand for adjustable-speed, alternating current drives in steel mills.

An improvement in alternating-current, adjustable-speed drives has been made by the building and placing in successful operation of one 770-hp. and two 1,600-hp. equipments of the double-range, frequency-converter, constant-torque type. Speed variation is obtained by means of a frequency converter on the same shaft as the induction motor. This frequency converter is the only auxiliary rotating machine required.

Roughing stand drive in strip mill of Acme Steel Co., Chicago, Ill.

A Westinghouse 1,500-hp., 705-r.p.m., wound-rotor induction motor drives the roughing stands of a 20- 16-in. hot strip mill, through a Farrell Foundry & Machine Co. reduction gear.





Motor room of the new continuous strip sheet mill of the Columbia Steel Co., Butler, Pa.

At the right are three General Electric motor-generator sets supplying direct-current power to the four adjustable-speed, 2,000-hp., 200/400-r.p.m., motors at the left. These motors drive four-high mills in a new process for producing continuous sheets and strips.

The frequency-converter slip rings are connected to a transformer supplied with 25 cycles from the line; the commutator end of the frequency converter is connected to the slip rings of the main motor. This arrangement always gives the correct frequency to introduce into the induction motor rotor. The initial adjustment of phase position is accomplished by making the frequency converter frame so that it may be rotated slightly, and when once adjusted the frame can be doweled in position. Speeds of 10 per cent and 5 per cent above or below synchronism are obtained by taps on the transformer. At synchronous speed the induction motor rings are short-circuited. Power factor improvement up to about 100 per cent at full load is obtained by means of a tertiary winding on the transformer, supplying a small out-of-phase voltage which is added to the speed regulating voltage.

Several installations have been made of adjustable-speed, induction motors using the Kraemer and Sherbius systems of speed control. Among these there should be mentioned two unusual Kraemer drives forming part of the electrical equipment for the 21-in. sheet bar and skelp mill at the Indiana Harbor plant of the Youngstown Sheet and Tube Co. These drives are shown on page 253. The first motor is rated 3,600/1,940-hp., 290/156 r.p.m. and the second motor is rated 7,500/4,040-hp., 250/134 r.p.m. These drives are unusual in that the direct-current motor, which is a part of the Kraemer system and is ordinarily direct connected to the induction motor, is in each of these cases used as part of a synchronous motor generator which supplies power to three 2,000-hp., direct-current finishing stand motors.

The Bethlehem Steel Co. is installing at its Sparrows Point plant a continuous sheet bar and skelp mill, three stands of which will be driven by a Scherbius, speed-regulating equipment rated at 6,700/5,000/3,320 hp. at 500/365/250 r.p.m. This is the largest Scherbius-controlled, induction motor in this country.

Constant Speed Drives—Although many modern mills require application of some type of adjustable-speed drive, there are still many cases where the cheaper and more satisfactory constant-speed drives are satisfactory. Wound-rotor motors are still used in many instances, but mill operators are showing considerable interest in synchronous motors, and some applications have been made.

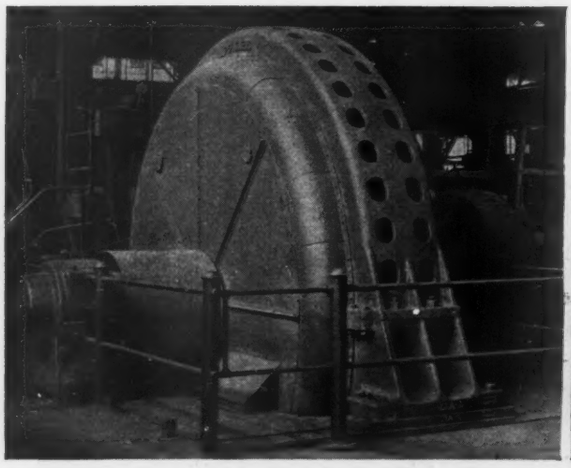
The first eight stands of the continuous sheet bar and skelp mill being built by the Bethlehem Steel Co. will be driven by two synchronous motors, one being rated at 4,000 hp., 83 r.p.m. and the other at 6,500 hp., at 187 r.p.m. A 1,500-hp., 62½-r.p.m. synchronous motor has also been installed at the plant of the Gary Tube Co.

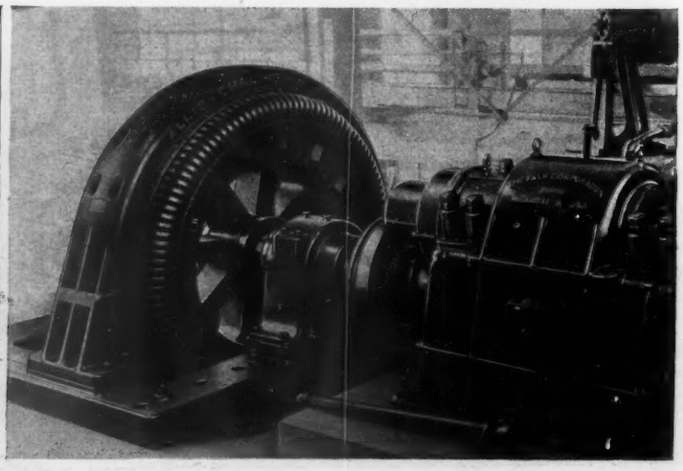
The use of the three synchronous motors on the mill just mentioned and the recent purchase of a 5,000-hp., 240-r.p.m. synchronous motor by the Standard Seamless Tube Co. for driving a piercing mill, follow the successful application and operation of the 9,000-hp. synchronous motor at the Cleveland plant of the McKinney Steel Co. This motor has now been in successful operation for about a year and is said to have met all of the demands of the mill, both in starting and running, without difficulty.

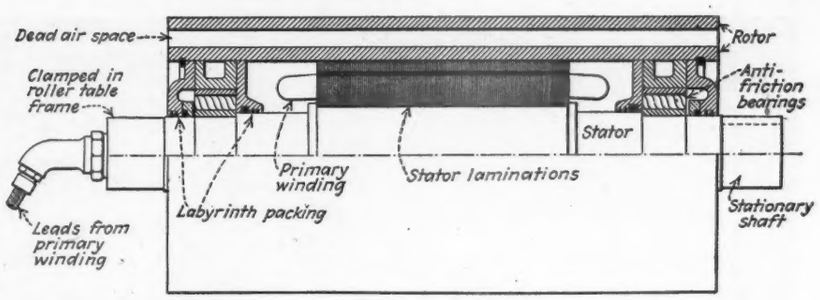
A 5,000-hp., 99-r.p.m., three-phase, 60-cycle, 13,200-volt, wound-rotor, induction motor has been built for a continuous billet mill drive. The motor is of particular interest in that it is the first mill drive built by Westinghouse for operation on higher than 6,600 volts. Also due to the

The synchronous motor is coming into its own as a constant-speed drive in steel mills.

At the left is an Allis-Chalmers 1,500-hp., 6,600-volt, 62½-r.p.m. synchronous motor in a seamless tube mill at Gary, Ind. On the right is a 2,500-hp., 257-r.p.m., self-starting synchronous motor driving a piercing mill at the Milwaukee plant of the Globe Steel Tubes Co., through a Falk reduction gear.







New motor roller that has been developed in Germany.

This roller has a self-contained induction motor. The shell revolves, the central part and stator winding remaining motionless. Self-contained, anti-friction bearings support the shell.

slow speed, the motor is of exceptionally large diameter.

Reversing Mill Drives — A most important development in the last two years in the electrical equipment for reversing mill drives is the perfection of a system of parallel connections for the direct-current generator, so as to assure equal division of load under all conditions, thereby permitting the use of large single-armature reversing motors in place of the double-unit motors formerly used. During the past year there was placed in service an 8,000-hp., 40/80-r.p.m., 700-volt, single-armature reversing motor, as the drive for a 54-in. blooming mill. This is the largest single-armature reversing motor yet built. Power for its operation is supplied by two 3,500-kw., 700-volt generators operating in parallel. Six 7,000-hp., 50/120-r.p.m. 700-volt, single-armature reversing motors are now in service.

Another very interesting application of reversing motors is the use of separate motors for the main and edging rolls of the universal roughing and intermediate stands of a 52-in. structural mill. The main rolls are driven by a 7,000-hp., 50/120-r.p.m. reversing motor, and the edging rolls are driven by a 2,000-hp. 57/163-r.p.m. reversing motor. The characteristics of the motors are so proportioned that the two motors have the same inherent relative rates of acceleration and retardation. Also, the control is so arranged that the ratio of the speeds of the two motors may be changed to take care of changing roll diameters.

Application of Auxiliary Drives

STANDARDIZED Mill-Type Motors—A new line of steel mill motors, to be known as the MD-400 series, has been developed by the General Electric Co. These motors, designed in collaboration with the Standards Committee of the Association of Iron & Steel Electrical Engineers, are said to meet the specifications of that body and are the first motors on the market to do this. These motors are of the roller-bearing type, although sleeve bearings can be supplied at the option of the purchaser. A more detailed description is given on page 298.

Early this year the manufacturers and the Standardization Committee of the Association of Iron & Steel Electrical Engineers reached an agreement on the final dimensions for the Standardized Mill-Type Commutating Pole Motor. The agreement calls for seven frame sizes having the following 1-hr. or mill ratings: 7½ hp., 10 hp., 15 hp., 25 hp., 35 hp., 50 hp., and 75 hp.

For each of these sizes of motor standard over-all dimensions, standard shaft tapers and keyways, standard pinions, gears, and gear ratios, standard axle shafts, and standard anti-friction bearings have been agreed upon.

Motor Rollers—An auxiliary drive development of considerable interest is the Motor-Roller. This is a roller for use in roller tables. Instead of being geared to a lineshaft as is customary with roller tables, each roller is driven by a self-contained motor.

The roller consists of a shell or cylinder which is mounted at the ends on anti-friction bearings so as to revolve on a stationary shaft extending through the roller as illustrated at the top of this page. On the shaft between the bearings is placed the primary winding of an induction motor; this winding is on the stationary shaft in place of being in the stationary housing of an ordinary motor. The leads from this winding are taken out through the center of the shaft which is supported in a frame carrying other similar rollers so as to make a roller table. The shaft is supported outside of the bearings.

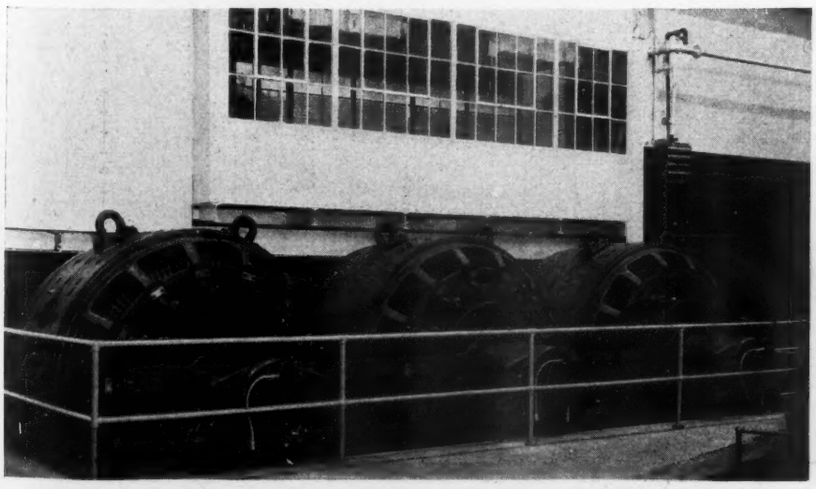
As stated in the caption above, the Motor-Roller is a German development. It is being manufactured in America by the Reliance Electric and Engineering Co. for the Schloemann Engineering Co., Pittsburgh, Pa., which is the sales representative for the device.

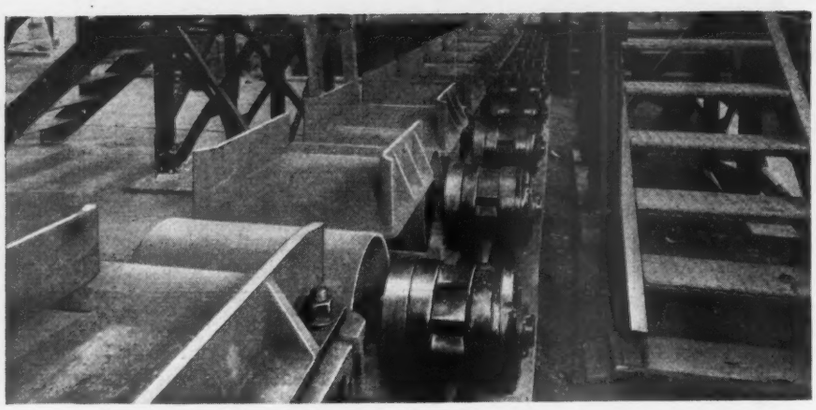
Direct-Connected Hot Saws — Direct-connected hot saws for cutting rails, shapes and the like, have recently been perfected. In the past the common practice has been to use a belt for this drive. This was due to the fact that a direct-connected motor would necessarily have to be mounted in a position normally exposed to the intense heat radiated from the metal being cut.

In the new saw, the motor and bearings are shielded from the extreme heat of the metal by a water-cooled plate or tank which is placed

Adjustable-speed, direct-current motors driving the finishing stands of a continuous sheet-bar and skelp mill.

These three 2,000-hp., 85/165-r.p.m., direct-current motors are in the Indiana Harbor plant of the Youngstown Sheet & Tube Co. This is a close-up view of the motors shown in the left background in the illustration at the bottom of page 253.





The trend is towards use of individual motor drive on table rollers.

This is the hot bed runout table in the new strip mill of the Acme Steel Co. Each roller is driven by a Westinghouse ½-hp., squirrel-cage motor running on anti-friction bearings. The bearings on the roller are also of the anti-friction type. Note that the motor is supported on one side only.

between them and the hot metal. This baffle is curved to conform to the shape of the motor frame. Water is fed to the baffle at the flywheel end of the motor and discharged against the saw.

Ward Leonard System on Ore Bridges—During the past year the Ward Leonard system of control has been used for operating ore bridges and car dumpers. A car dumper in Ohio is equipped with two 450-hp. motors on the cradle hoist and two of the same rating on the mule haul. Power is furnished through two motor-generator sets, each consisting of two 375-kw. generators, driven by a 1,100-kva. synchronous motor. The voltage of the generators is varied to control the motors by the Ward Leonard system.

* * * *

Application of Motor Control

GROWING evidence of the reduction of manpower that can be accomplished by the application of automatic control is shown in many lines of steel mill operation. Automatic charging of blast furnaces has been advanced to the point where only one man (the scale car operator) is required. This result is obtained through the use of bin gates in the stock house that can be operated by one man either by air or by means of motors, and by so sequencing and interlocking the skips, revolving top on the furnace, the small bell and the large bell, that each drive functions at, and only at, the proper time. The scale car operator selects the desired charge from the proper bins, hauls it to the skip and starts the skip on its way. The skip carries the charge to the furnace top and causes the remaining drives to function in proper succession. Several installations of this character are being considered at the present time.

An electric stock-line recorder has been developed by the Freyn Engineering Co. for automatically recording on a chart the depth of the stock line in a blast furnace. This is of particular interest due to the fact that clever use of automatic control is utilized in its operation. At predetermined intervals usually after each dump of the big bell, a try rod is lowered by means of a motor-driven winch. The motor lowering the try rod is controlled by dynamic braking. As soon as the try rod hits the burden the dynamic current becomes zero and the automatic control is actuated to hoist the try rod to the top of the furnace where it is stopped by a limit switch. The number of revolutions made by the winch in lowering the try rod is recorded on a chart, thereby giving the blast furnace superintendent a complete record of the stock-line level for a 24-hr. period.

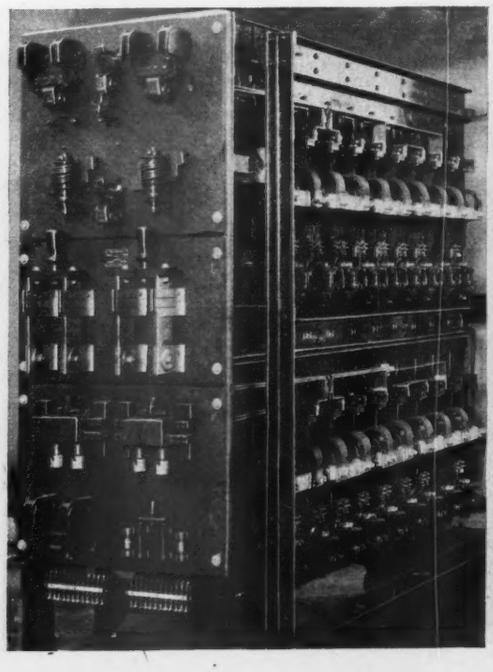
Thus it serves as a check on the frequency of filling and maintenance of stock level in the furnace. Also, it is done without the supervision of an attendant.

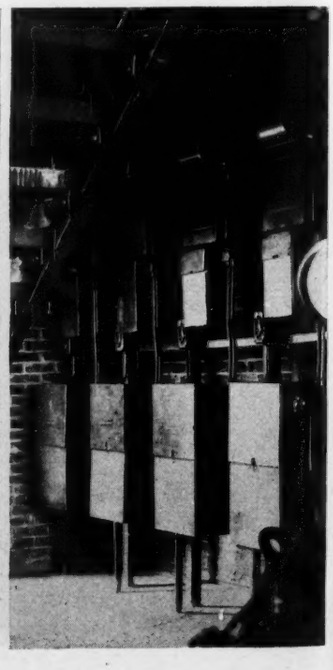
The installations of time-limit control are steadily increasing. Although the larger portions of these installations has been for the control of mill tables and other auxiliary drives, a very considerable number have been installed for the control of open-hearth charging machines, soaking pit cranes and standard cranes, particularly for the bridge motions. Installations of particular interest include a dynamic lowering controller for a bucket hoist and an ore bridge trolley controller. One large western steel plant has during the past year installed 75 inductive-time-limit control panels.

Aside from the familiar dashpot type, magnetic-time-limit type, and inductive-time-limit types of control acceleration, numerous devices to provide definite time for acceleration have been designed for both alternating and direct-current magnetic

Two of the newer developments in mill-type control.

At the left is the control for two 275-hp., 230-volt, direct-current motors which operate in parallel on a shear. This control is of the electro-pneumatic type and makes a complete cycle of operation every 6 sec. At the right are shown four Rowan impedance starters controlling 50-hp. pump motors in an Eastern tin mill.

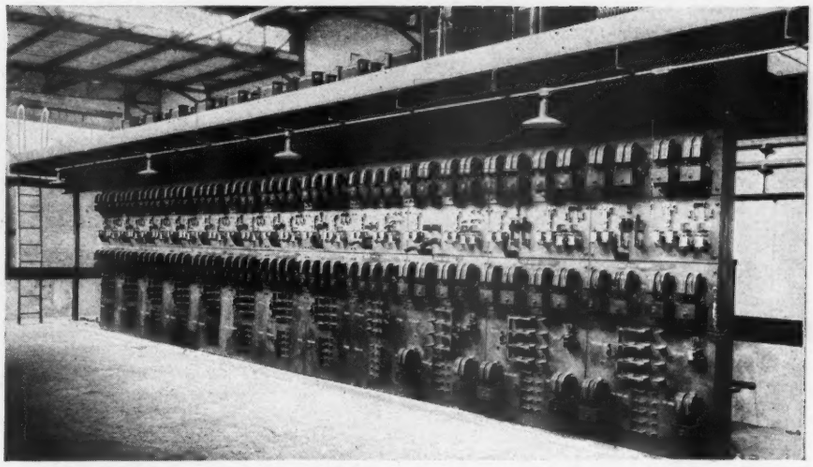




controllers. In one form a solenoid puts spring tension on a shaft which at different angles of rotation closes successive contacts short-circuiting blocks of resistance in the motor circuit. These fingers are retarded in their closing by means of an escapement mechanism, the pendulum of which is adjusted for different time intervals. Relays using this same principle have been applied to control contactors successively cutting out resistance in the rotor circuit of slip-ring induction motors.

Improvements have been made in the control for front and back roll tables in reversing blooming mill drives. Two master switches are used, the No. 1 master rotating the tables toward the mill and the No. 2 master rotating the tables away from the mill. In normal operation only No. 1 master is used, the steel issuing on to a dead table. The No. 2 master is used only when the piece becomes long or to convey the piece away from the mill after rolling is completed. On mills with well-aligned roll table bearings, the rolls will often continue drifting from the previous pass, to such an extent that metal issuing to them on a succeeding pass will be drifted back into the mill. With the new control dynamic braking is applied to the drifting tables as soon as the other motors are energized, thus stopping the tables and preventing the metal from being returned to the mill until the master switch has been moved to the opposite position.

An electro-pneumatic controller has been applied to the control of two 275-hp., 230-volt, direct-current motors operating in parallel on a cutting-off machine. This controller is shown on page 250. A complete operating cycle (consisting of accelerating, cutting, braking, reverse and return to starting position), every six seconds, is made possible by this control. Magnetic contactors of the size required, would have been too sluggish for this application. In addition, the electro-pneumatic control is said to be much more compact and rugged than would have been the case with magnetic control. This controller has been operating under severe service for several months and is said to be giving very good results.



Time-limit acceleration for motor control is preferred in many mills.

These General Electric magnetic-time-limit panels are in the 28-in. structural mill of the Lackawanna plant of the Bethlehem Steel Co. Spare panels are provided which may be substituted for any panel in an emergency by means of the transfer switches shown on the bottom section of each panel. Notice the arrangement of resistance on a gallery.

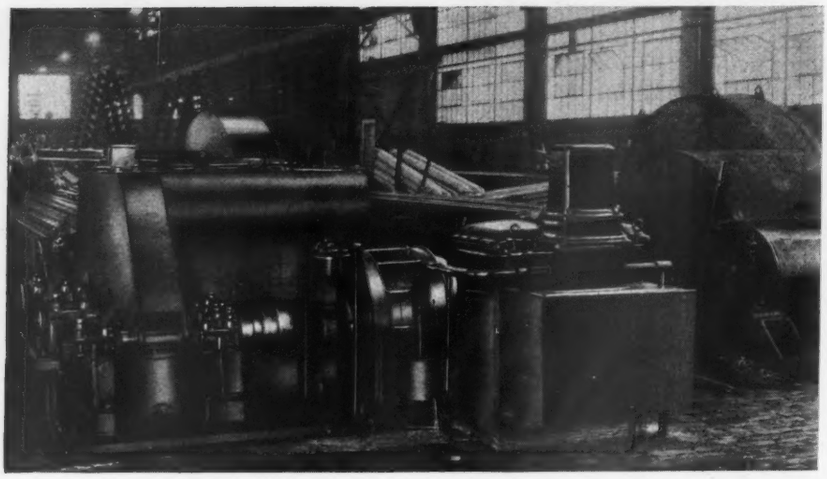
Two new magnetic brakes have recently appeared on the market. One of these, the Type WB designed by the Electric Controller & Mfg. Co., has been developed to meet the demand for a shoe-brake giving longer life of brake-shoe linings and permitting quick removal of the motor armature with the brake wheel in place, without the necessity of taking the brake apart or disturbing any of its adjustments.

An alternating-current brake has been developed by the Clark Controller Co. Due to the novel arrangement of operating levers, this brake is said to close on the brake wheel according to the spring pressure only, thereby giving no hammer blow due to the momentum of the magnet armature. The mechanical half of the brake is similar to the direct-current brake that has been manufactured by this company for the past two years.

A relatively new starter for squirrel-cage induction motors is said to

There is a trend towards the substantial installation of control.

This Cutler-Hammer inductive-time-limit control is located in a control house of a large steel mill in the Youngstown district. At the left is shown the upper floor of this brick control house. Only resistors are located on this floor. Resistors are individually supported and may be removed without disturbing the others. The floor is made of iron bars so as to secure good ventilation. At the right is a view of the first floor on which the control panels are located.



Here is a synchronous motor control so enclosed and protected that it may be installed out in the mill.

This is an Electric Controller & Mfg. Co. control for a 100-hp., 2,300-volt, synchronous motor driving a draw-bench. In this location it is subjected to the dirt and dust of a pipe mill.

be growing in favor for steel mill application. This starter is the Rowan impedance starter, utilizing impedance in series with the motor for starting, instead of resistance. The starter is oil-immersed, which fact is said to enable it to operate satisfactorily under the varying atmospheric conditions encountered in steel mills. A steel mill installation of these starters is shown in the illustration on page 250.

A new oil-immersed starting switch, especially designed for steel mill service has also just been placed on the market by the Rowan Controller Co. Immersing the switch in oil is said to eliminate corrosion and mechanical wear as well as give it large reserve capacity and assist the overload protection in functioning properly.

An increasing demand is noted for completely enclosed and self-contained equipment for starting synchronous motors. Equipment that has been almost standard in the past consists of a hand-operated oil switch and field switch mounted on a switchboard, suitable for substation installation. A modern installation for controlling a 100-hp., 2,300-volt synchronous motor driving a draw bench is shown in the illustration at the top of this page. As may be seen, this installation is beside the motor out in the mill.

Mechanical Elements of Power Drive

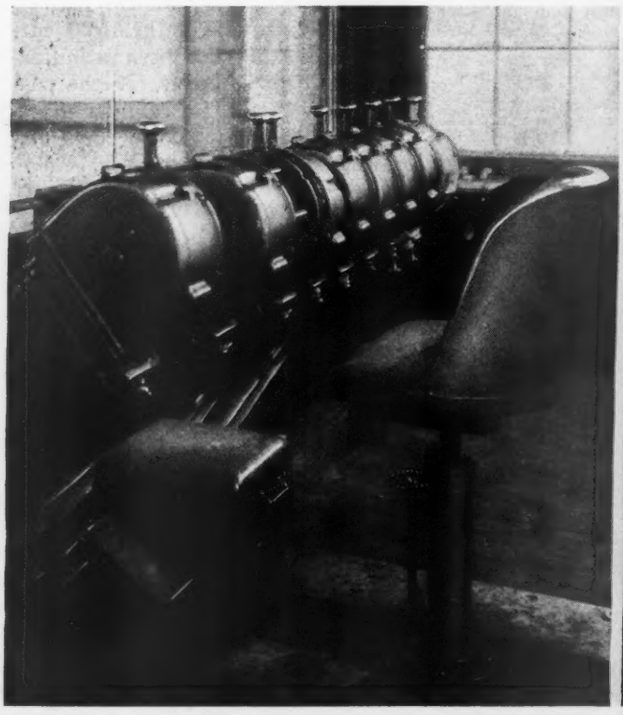
BEARINGS—It was only a short time ago that consideration was given to the application of ball and roller bearings to motors in the steel industry. Today there is practically no application in the steel plant for which the anti-friction bearing is not being considered as a possibility.

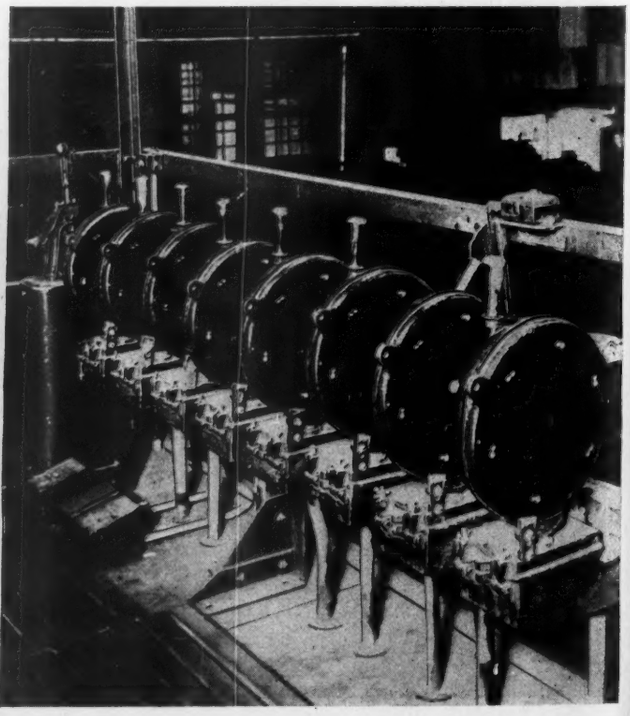
Extensive application of anti-friction bearings has been made to traveling cranes in all of the principal positions—drum shafts, back-shafts, trolley and bridge trucks, reduction gears, and bridge lineshafts, to say nothing of the motor bearings. Due to their inaccessibility, bearings on cranes are very frequently neglected. Oil is not suitable as a lubricant as the motion of the crane tends to throw it out of the enclosures. Grease-lubricated bearings will run from six months to a year without attention and the possibility of oil drip is eliminated.

One mill builder advises that for some time he has been furnishing anti-friction bearings on roll tables,

Master switches with "plug-in" bases are in use in several plants.

At the left is a General Electric installation in the 35-in. structural mill at the Lackawanna plant of the Bethlehem Steel Co. By removing three wing nuts the entire master may be removed and a new one plugged in. Note the foot-operated master for controlling the main drive reversing motor. At the right is a Westinghouse installation of "plug-in" master switches.



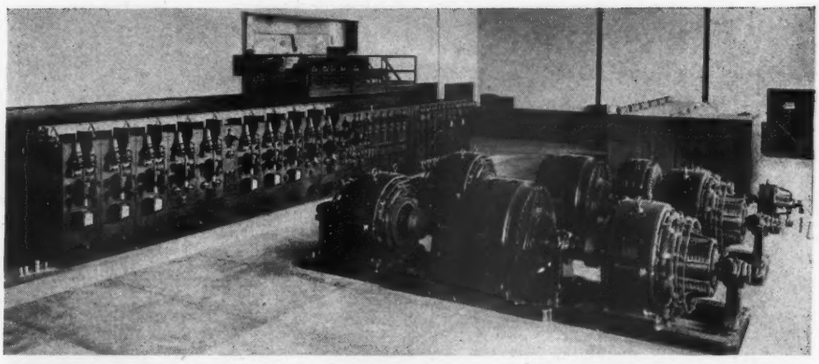


manipulators and similar steel mill applications.

Great interest is being shown in the application of anti-friction bearings to roll necks, that is, journals of rolls used in rolling steel. As early as three years ago, an installation was made in an 11-in. bar mill in the plant of Withowitz, in Czechoslovakia. This installation is said to have been very successful. Tests show that the friction load, while idling with anti-friction bearings, was 69 per cent less than that with standard bearings. In addition to the saving in power a claim is made for less change in section, resulting in less weight tolerance to be taken care of. It is also stated that very little lubrication is required, the grease being forced into the bearings mainly to insure the exclusion of water and sinter.

The Timken Roller Bearing Co. has made an installation of roller bearings in its 16-in. and 22-in. mills. This company states that a saving of power consumption is obtained, tests on the 16-in. mill showing an average of 44 per cent. This company further states that a higher grade of product can be maintained due to the greater ease of holding the sections.

There are a number of mills being put in at the present time with anti-friction bearings on the roll necks, one of the first being that built by the United Engineering & Foundry Co. for the Rome Wire Co., Rome, New York. The Youngstown Sheet & Tube Co., Lukens Steel Co., Allegheny Steel Co., Laclede Steel Co., Columbia Steel Co., Weirton Steel Co., Trumbull Steel Co., and American Steel & Wire Co., are all installing mills that will have anti-friction bearings incorporated on the roll necks.



Motor rooms are becoming more elaborate and yet more compact.

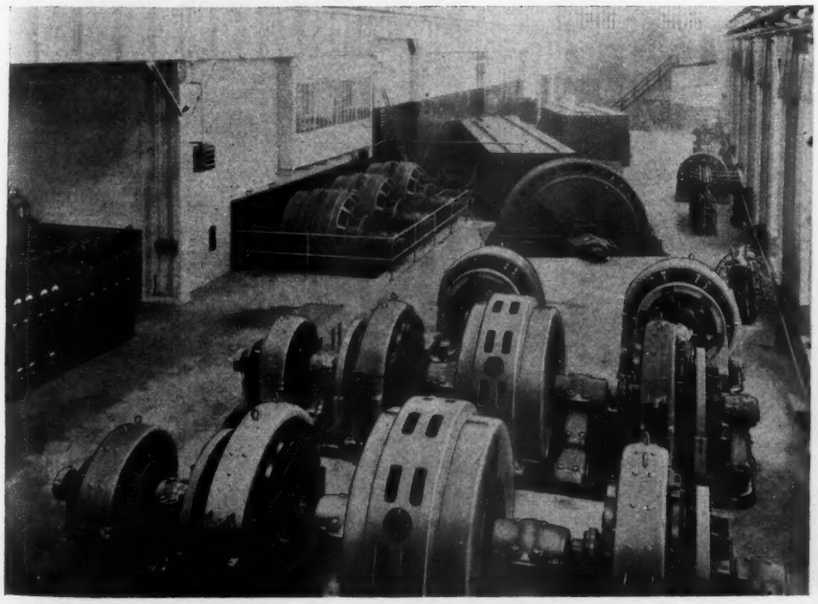
Here is the motor room and substation for the hot strip mill of the Acme Steel Co. At the left are the direct-current panels for controlling adjustable-speed motors on main drives. In the center background are a.c. panels controlling truck-type switches in the right background which supply motor-generator sets at the right. This is a Westinghouse installation.

Most of the above mills are for rolling strip or sheets. Some are on four-high mills for rolling thin steel strips. One manufacturer has sold 35 such stands within the last 18 months.

Meanwhile increasing use is being made of ball and roller bearings in motors. The Youngstown Sheet & Tube Co. has changed a large number of armatures for use with roller bearings; this company has this year changed over one hundred motors so as to permit the use of roller bearings.

There are over 17,000 hp. in motors in this steel mill substation.

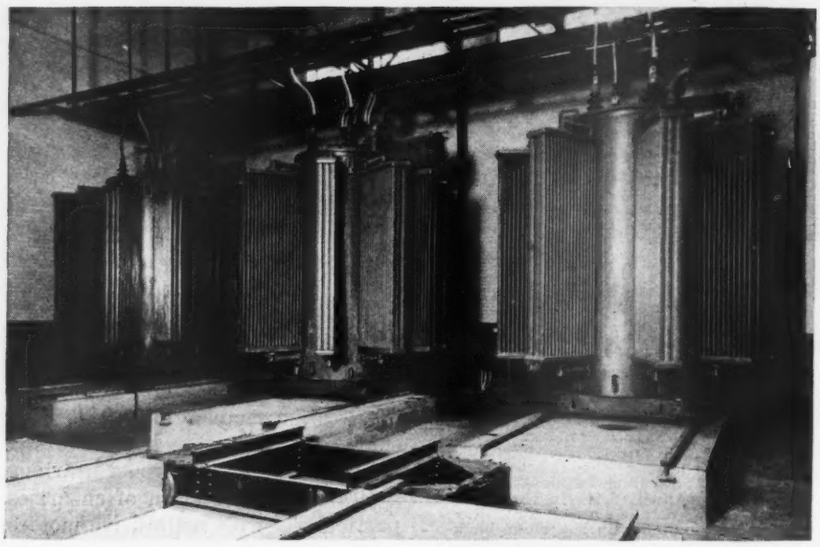
In the foreground are two motor-generator sets supplying the three 2,000-hp., adjustable-speed, main drive motors shown in the left background. In the center background is a 7,500-hp., Kraemer set. Further in the background (cannot be seen) is a 3,600-hp. Kraemer set. This equipment is in the Indiana Harbor plant of the Youngstown Sheet & Tube Co. It is a General Electric installation.



Gears—The question often arises, particularly with main drive motors, as to whether the drive should be geared or direct connected. Gearing may reduce the over-all cost and permit using duplicate motors on the various stands. A high-speed motor is generally less expensive than a slow-speed machine. At a recent meeting of the Association of Iron & Steel Electrical Engineers, H. A. Winne of the General Electric Co., stated that unless the high-speed unit runs two to three times the mill speed, its cost added to that of the gear will be more than that of the direct-connected motor. In other words, he said, unless the gear ratio can be made at least 2:1, the gear had probably better be omitted. The gear ratio will be determined by the mill speed and the maximum desirable motor speed; this latter, in turn, is fixed largely by the capacity of the drive.

Geared main drives are used to a large extent in many new steel mill installations. However, these, like many of the smaller drives, are becoming more on the order of a large speed reducer, with cast-iron cases and pressure lubrication, using filtered oil that is recirculated.

Speed reducers for smaller auxiliary drives are finding favor in all applications where a large reduction in speed as well as a compact installation are required. The Falk Corporation has brought out a new and improved line of standard speed reducers featuring continuous-tooth herringbone gears and an improved lubricating system. The Tool Steel Gear & Pinion Co. has also developed a line of speed reducers featuring their Tool Steel gears, heat-treated, chrome-nickel steel shafts and a built-in pump for supplying forced lubrication to the moving parts. The worm gear speed reducer is



Here is a typical steel mill transformer substation.

These three Westinghouse, 3,333-kva., 12,000/2,300-volt, self-cooled, transformers are in the plant of the Acme Steel Co. The transformers are permanently mounted on small trucks that may be pushed to the large truck shown in the center and then taken out of the substation.

popular in many mills. In fact several worm gear reducers have been specially developed for steel mill service.

However, there are many geared auxiliary drives where the standard speed reducer does not fit in and special gearing is required, as on mill tables, cranes, and the like. There is a distinct tendency towards total enclosure of these gears, thereby permitting them to run in an oil bath.

Flexible Couplings—Reversing mill motors are usually connected to the lower mill pinions by couplings of the universal or common grab type. Recently large flexible couplings were installed on two 34-in. blooming mills driven by 3,500-hp., 50/120-r.p.m. reversing motors. These motors are each capable of exerting emergency torques of 1,000,000 lb. ft. They represent, therefore, the heaviest service to which flexible couplings have as yet been applied.

Lubrication — Forced lubrication is becoming almost the rule in new mill installations. A merchant mill recently completed in the Chicago district utilizes three Bowser oil filtering units. One unit furnishes oil to the gears and bearings on the universal mill, the second unit distributes oil to the three sets of reduction gears and bearings and also to the pinion gears and their bearings on the remaining stands of the mill, while the third unit serves the bearings on the motors and flywheel motor-generator set driving the mill. The oil used in the first two units is heavy and will congeal in cold weather. Hence, all oil lines running to and from these units are heated with low-pressure steam pipes incased in the insulation covering the oil pipes. Each receiving tank, filter, and pressure tank is provided with heating coils.

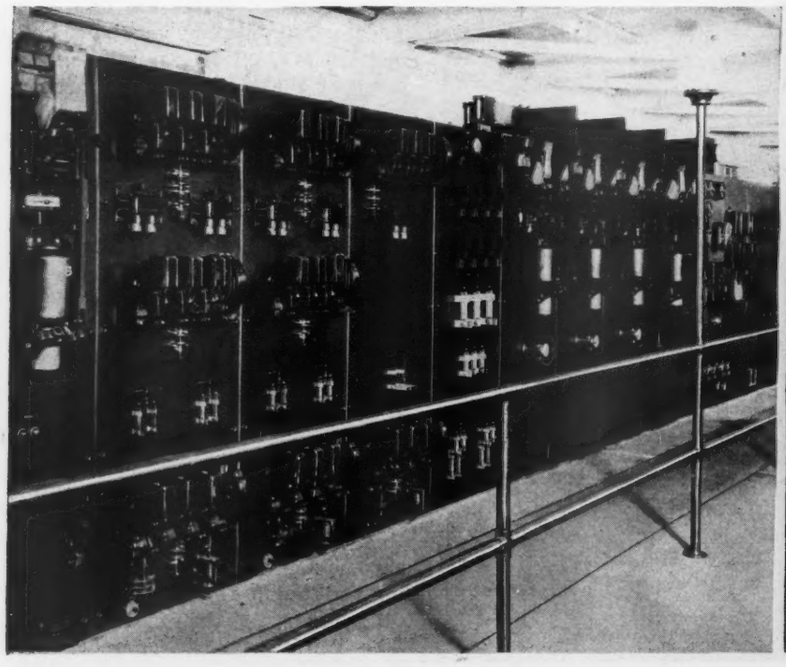
* * * *

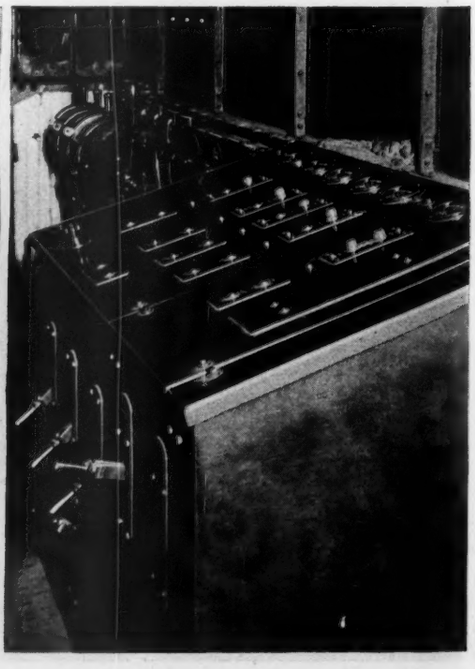
Distribution and Conversion of Power

AUTOMATIC Substations—The use of automatically controlled substations in steel plants has increased very greatly since the first installation in 1924. Many plants have found automatic control so reliable that they are changing over their existing manual stations. Others are installing either complete or partial automatic equipment provided with push-button, starting and stopping stations. In some cases an operator will be maintained at these stations simply to start and stop the equipment and at other times to act as a watchman. The change is due to the demonstrated superior accuracy, rapidity, and reliability of

Switching and control panels for over 10,000 hp. in main drive motors.

These panels control the four main drive motors in the cross-country mill of the Wisconsin Steel Co. At the right is the operator's pulpit and control desk.





automatic control as compared with manual control.

One plant has considered these features as of sufficient importance to warrant the installation of automatic switching equipment for synchronous motor-generator sets and auxiliary direct-current feeders in a large *attended* substation which also houses several large structural mill drives.

The Commonwealth Steel Co. has placed in operation at its Granite City (Ill.) plant, a two-unit, automatically-controlled, synchronous motor-generator station with counter-e.m.f. regulator control. One generator is rated at 1,800 kw., and the other at 900 kw. Both furnish power at 250 volts direct current to the steel foundries of this company.

The Youngstown Sheet & Tube Co. has installed two automatically-controlled motor-generator sets in its new tin mill at Indiana Harbor, Ind. Installation of automatic substations has recently been completed by the Illinois Steel Co., Lorraine Steel Co., and others.

Switching — The advantages of truck-type switching equipment have been appreciated by many steel plant operators, and several large installations of truck-type switches are being made. The ease of replacing any damaged truck by a spare truck circuit breaker may in some cases warrant the installation of a single feeder breaker, whereas with cell-mounted breakers it is considered necessary to install duplicate apparatus to protect the service adequately.

The first isolated-phase switching equipment in an industrial plant was installed in the new generating station of the Franklin works of the Bethlehem Steel Co. at Johnstown, Pa. This initial installation was followed by others in the plants of the Illinois Steel Co. at Gary, Ind., and the Jones and Laughlin Steel Corporation at Woodlawn, Pa.

Distribution—Many steel plants have reached and passed the economic limit of 2,200 volts for distribution. The large amounts of power required by some mill drives result in prohibitive current values at this voltage. This is reflected in higher cost of protective oil switches and line losses even in the relatively short transmission distances from the load center to the numerous mill motors.

A distribution voltage of 6,600 has become quite common. The increasing loads in the larger plants, however, are taxing even the 6,600-volt systems, but so far there have been reported very few installations of main drive motors fed directly from a 13,200-volt system. One such motor rated at 5,000 hp., 99 r.p.m., has been installed on an 18-in. continuous billet mill drive at the River Rouge plant of the Ford Motor Co.

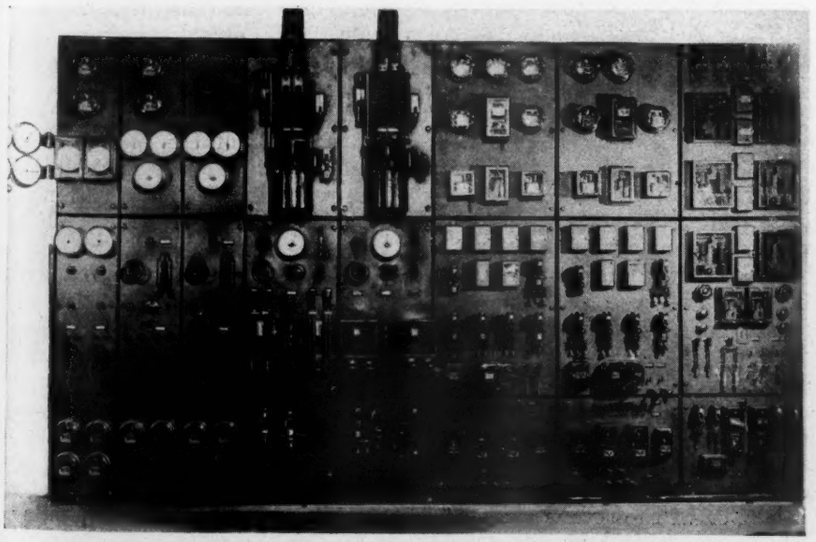
Power Factor—An interesting development is the automatic power factor regulator that has been recently brought out by the Electric Controller & Manufacturing Co. This consists of a contact-making, power factor meter and two relays for controlling a motor-operated or solenoid-operated field rheostat. The principal application for this device will be to maintain approximately constant power factor in a plant. By connecting the instrument somewhere near the center of distribution and adjusting the high and low contacts for the desired range of power factor, the regulator will control the setting of the field rheostat of a large synchronous motor so as to keep the power factor of the system approximately constant.

Ventilation—Ventilation of electrical equipment and of the motor rooms is receiving careful attention on new layouts. With the installation of several large machines in a comparatively small sub-station, as is the case in many of the newer mills requiring large amounts of power, the losses are greater than can be easily dissipated by natural ventilation. Artificial ventilation also is of advantage in keeping the motor room cool. With the motor room under slight pressure, mill dust is largely kept out and the motor room is made cleaner. There is also the possibility of increasing the rating of the machines by artificial ventilation. The water spray or wet washer is still used in some plants for air conditioning, although there is a tendency toward the use of the dry types of filters.

On account of the high flood level of a small stream flowing through the property of the Phoenix Iron Co. it was not practicable to have basements under the motor rooms, in which to place the ventilating equipment. Hence, the air washers and fans were located on the floor of the motor room. All of the air ducts are lined with ¼-in. steel plates and all joints riveted and electrically welded, so as to prevent seepage of water into the ventilating system.

Increasing use is being made of automatic substations in the steel industry.

This Westinghouse automatic equipment controls synchronous motor-generator sets and feeders in a large steel plant in the Pittsburgh district.



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Illumination—Safety Electric Heat

Illumination—Marked impetus is noted in the recognition of the value of good lighting in mill yards and buildings. More attention is being paid to the specific requirements of different kinds of mills and to the different operations within a given mill. Special pains are being taken to make the lighting units accessible for repair and cleaning.

Floodlighting of yards, docks, and areas in which work is conducted at night, is receiving much more attention than formerly. Also, more efficient and larger lighting units have

(Please turn to page 275)

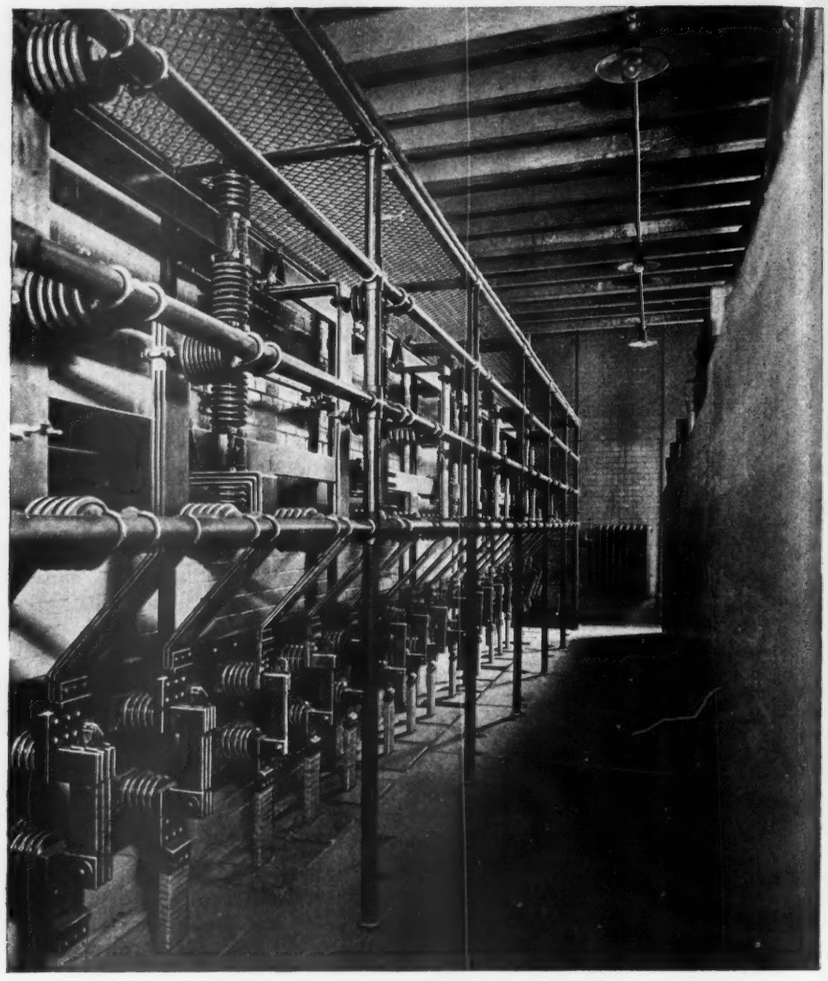


Fig. 1 — This view shows a typical industrial plant installation with standardized unit-type bus supports and disconnecting switches

Considerations that influence

Layout of Heavy Bus Structures

in industrial plants

By W. H. BOYCE
Designing Engineer, Delta-Star Electric Co., Chicago, Ill.

IN THE design and construction of all bus work there are certain fundamental facts that should be given careful consideration by those who may be called upon to select and install such equipment. It is the purpose of this article to outline some of these facts in a general and practical way, without going too deeply into the mathematics involved.

Practically every bus installation presents problems of its own, in much the same way as the application of any piece of electrical apparatus for industrial use. For example, it is an obvious fact that the straighter a bus can be run, say, from a generator to the switchboard, the more economical it will be in the amount of copper and supports required. However, local conditions may be such that foundations, steam lines, other buses, and so on, may interfere, making straight-line construction impossible.

Many of the details involved in laying out an installation can best be settled by the engineer on the job, who is thoroughly familiar with the local conditions and the problems to be solved. There are, however, a number of features that are common to all installations and may be considered briefly. Before proceeding to outline the various methods employed for mounting the bus work, such as pipe and angle-iron frames, concrete cell structures, and so on, it may be well to review some of the factors governing the selection of the copper. Assuming that the maximum load current is known, the amount of overloads to be taken care of and their duration must be considered next.

Regardless of the voltage of the circuit, the first problem is to keep the heating of the copper within reasonable limits. Generally, the limits taken are those recommended by the former Electric Power Club (now known as Apparatus Division, National Electrical Manufacturers Association) and other bodies, which specify a 30-deg. C. rise over an ambient temperature of 40 deg. C., or a maximum operating temperature of 70 deg. C.

It is good practice to keep the temperature rise below these limits if

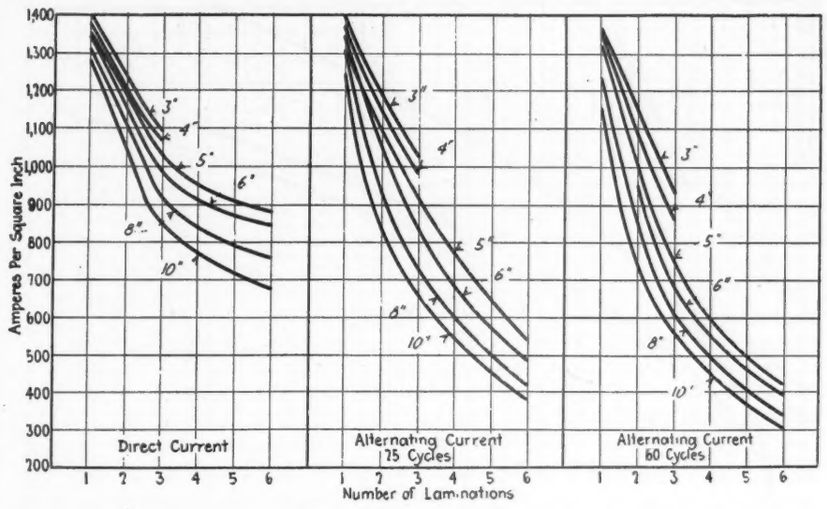


Fig. 2—These curves show the permissible current density in laminated copper busbars.

The busbar in the direct-current section was installed on edge in the open air with ¼-in. spacing between laminations. The curves in the 25- and 60-cycle sections are based on 8-in. spacing between phases and 30 deg. C. temperature rise above 40 deg. C. ambient temperature.

possible, and insofar as buses for direct current service are concerned, this means only providing sufficient copper to take care of this heating. On the other hand, the use of alternating current introduces other factors besides heating that must be taken care of, such as skin effect, mutual inductance between conductors, and so forth, that will be covered later in this article.

Assuming then, for the present, that we are dealing only with direct current, the next question to be answered is whether cables or bars shall be used for the conductors. With the exception of collector rails for cranes and locomotives, and certain classes of high-voltage outdoor construction, copper bars or cables are used almost universally. Aluminum has been used to a limited extent in certain process industries, where the buses would be exposed to the action of corrosive gases. The use of this metal presents certain problems in compensating for its expansion and contraction. Furthermore, aluminum has approximately only 60 per cent of the conductivity of copper. Consequently, at this time we will consider only the use of copper as bus conductors.

Where cables are used for buses they are invariably insulated for, or in excess of, the operating voltage. This is often a decided advantage from the standpoint of safety where there is the possibility of inexperienced workmen coming in contact with them. On the other hand, bare copper bar very often has the advantage of lower installation cost and can be worked at higher current densities on account of the increased radiation. Safe operating conditions can also be obtained in the majority of cases by means of suitable inclosures.

Local conditions will largely influence the selection of the conductor, but in general it may be said that for currents above 2,000 or 3,000 amp., it is advisable to use busbar rather than cable. The methods used for supporting and mounting various sized cables are in general much simpler than those required for busbars; so we will confine ourselves for the present to the latter.

It is standard practice with the majority of engineers to limit the current density in busbars to 1,000 amp. per sq.in., which is the equivalent of one 4 x ¼-in. bar. On this basis the maximum temperature rise for a single bar will be considerably below the 30-deg. limit. Referring to the chart shown in Fig. 2, it will be noted that the permissible density falls off very rapidly as the bars increase in width as well as in number. These curves are based on the performance of ¼-in bars mounted vertically. Where bars are run horizontally instead of vertically, the heating will be increased from 15 to 25 per cent, depending on the number of bars, due to the decreased

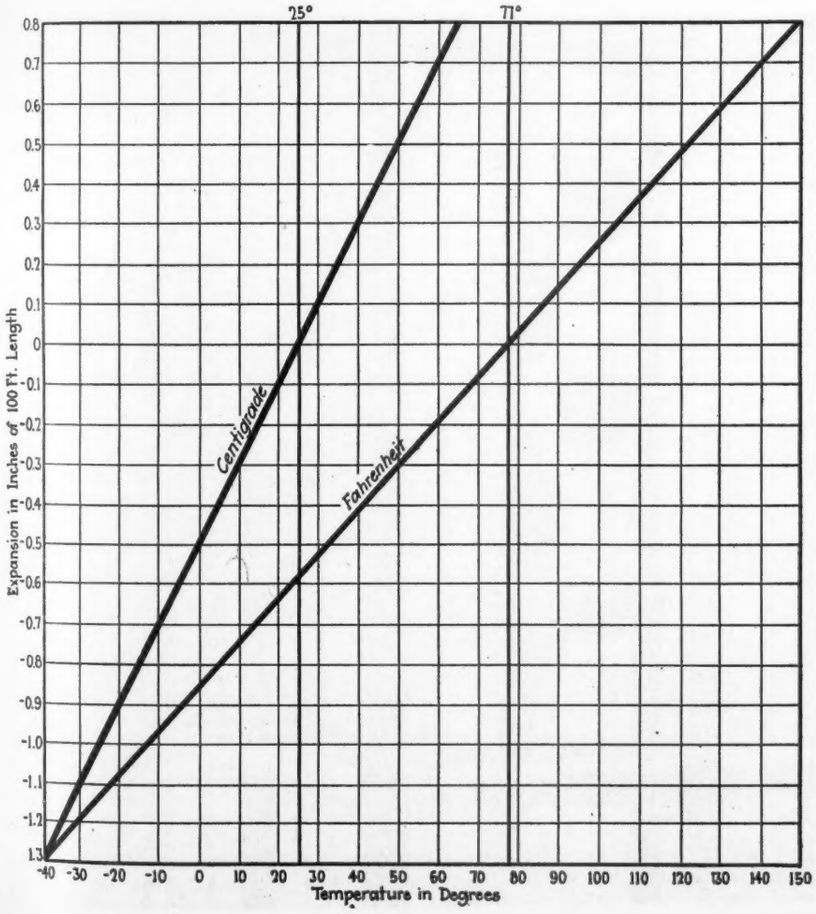


Fig. 3—Linear expansion curves for copper busbars.

For each 100 deg. F. increase or decrease in temperature there is 1 in. of expansion or contraction. This chart is based on the formula $L \times 0.0000092 \times$ deg. F. = expansion in inches.

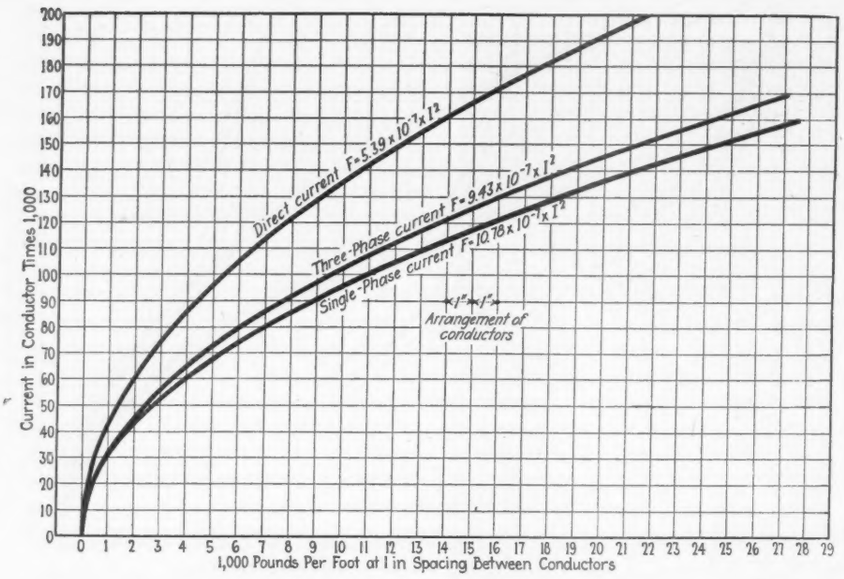

Current in Conductor Times 1,000
1,000 Pounds Per Foot at 1 in Spacing Between Conductors
Direct current $F=5.39\times10^{-7}\times I^2$
Three-Phase current $F=9.43\times10^{-7}\times I^2$
Single-Phase current $F=10.78\times10^{-7}\times I^2$
1"×1" Arrangement of conductors

Fig. 4—These curves show the magnitude of the electro-magnetic stresses in busbars at the moment of short-circuit.

ventilation and the mutual heating of adjacent bars.

If the bus run is not very long, no provision need be made to take care of the expansion and contraction of the copper. However, if the temperature variation is very great or the length of the run exceeds 50 or 60 ft., expansion joints or bends in the copper must be provided. The extent of this expansion and contraction with changes in temperature may readily be obtained by referring to the chart shown in Fig. 3, which gives the change in length of copper in inches per 100 ft. based on the formula,

$L \times 0.0000092 \times$ deg. F. $= E$,

where L equals the total length of the bus section in feet and E equals the increase or decrease in inches.

One of the most important considerations in installing buses is the insulation of the bus supports, for regardless of the operating voltage, the material selected should have the following characteristics: It must possess high dielectric strength; it should be non-absorptive, unaffected by ordinary temperature changes and should flash over before puncturing. In addition it should have high mechanical strength.

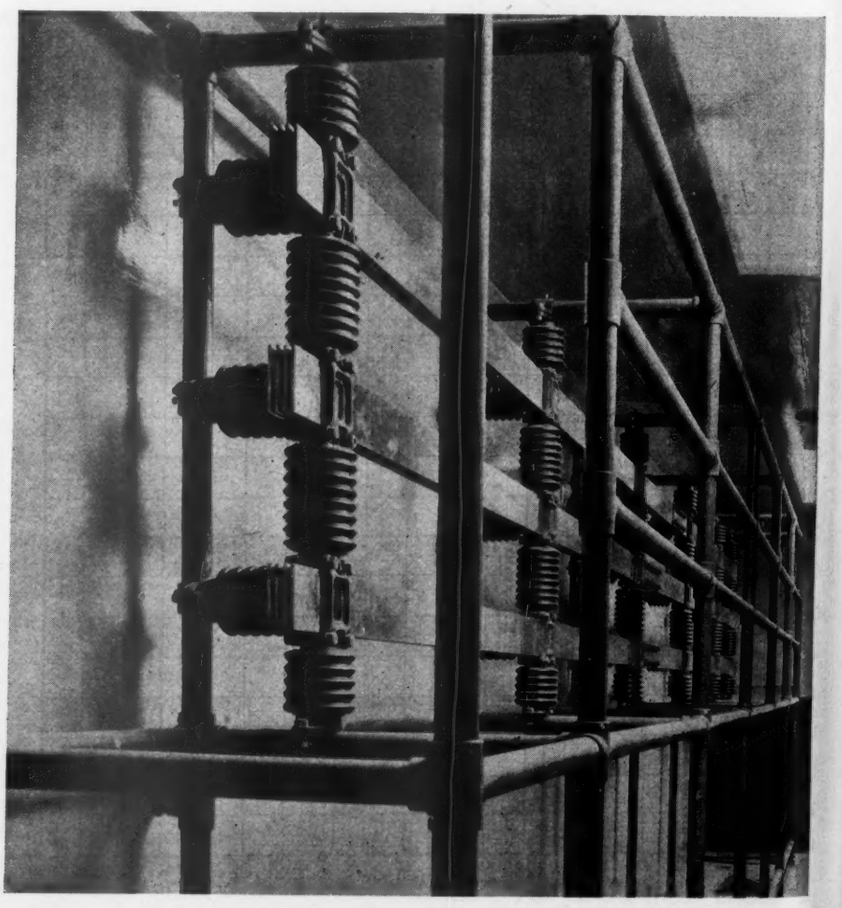
Wet-process porcelain has all of the above requirements and is used more universally than any other material.

The question of mechanical strength is of far greater importance than may appear at first sight, for not only must the bus support be able to carry the dead-weight load of the busbar, which, in the case of large buses, is considerable, but it must also withstand the enormous mechanical stresses that will be set up between conductors in the event of a short-circuit. Short-circuit currents are limited only by the capacity back of the bus and the amount of reactance in the circuit. Referring to Fig. 4, the curves therein show the relation between the current flow in amperes and the mechanical stress in 1,000 lb. per. ft. with 1-in. spacing between conductors at the moment of short-circuit.

In the average industrial plant it is very seldom that the total reactance in the circuit exceeds 10 per cent. This means for example, that where the maximum capacity is 3,000 amp., a dead short-circuit would mean a momentary current of 30,000 amp. Referring again to Fig. 4, we see that this would develop a force of 500 lb. per ft. Assuming a 5-in. spacing between conductors, this would be equivalent to 100 lb. per ft. and with the supports placed 5 ft. apart, would mean that the equivalent of a 500-lb. blow would have to be withstood momentarily by each support. There is a possibility in large installations of the short-circuit currents reaching a value as high as 75,000 or 100,000 amp.; so under these conditions, it can readily be seen that unless ade-

Fig. 5—In these standardized, unit-type, heavy-duty bus supports the porcelain is under compression.

Porcelain meets all of the requirements for satisfactory bus supports. It has more than enough mechanical strength to withstand the maximum force developed in busbars under short-circuit conditions.



quate provision is made for withstanding these large forces, the bus work will be completely wrecked.

Porcelain insulators of the type supplied by various manufacturers for use as indoor bus supports will have a cantilever strength varying from 500 to 4,000 lb., depending upon the size, voltage, and type. Very often, this is entirely inadequate to resist the disruption forces existing between buses under short-circuit conditions, as previously outlined. And yet these same insulators, when placed in compression, will have a total strength varying from 25,000 to 80,000 lb. This is far greater than the maximum force that would ever be developed under short-circuit conditions. Figs. 5 and 6 illustrate two general methods used in building up combination supports, placing the porcelain insulators under compression.

In connection with buses for alternating-current service there are several additional factors besides the heating effect of the current that have to be taken care of in the design of the bus. Referring back to Fig. 2, it will be noted that the carrying capacity of busbars in amperes per square inch falls off much more rapidly with alternating-current where the width of the bars as well as the number of laminations are increased. This curve can be followed where the maximum, average current does not exceed 2,500 or 3,000 amp., but above this point it becomes necessary to divide the bus into sections to take care of the so-called skin effect, edge effect and proximity effect of adjacent buses. When currents of 2,500 to 4,000 amp. are to be handled it is customary to divide the bus into two sections. This not only compensates for the skin effect of the current, but also gives better radiation due to the separation of the busbars into two groups. This type of construction is illustrated in Fig. 7.

For currents of 4,000 to 7,500 amp., the most economical arrangement of the bus copper can be made by dividing it into four sections, so arranged that the copper will approximate as nearly as possible, the condition that would exist if a tubular conductor were used. Two methods of doing this are shown in Figs. 8 and 9. Above 7,500 amp., it is necessary in most cases to split the entire bus into two or three sections, and by staggering the phases, as shown in Fig. 10, it is possible to neutralize to a great extent the effect of the heavy magnetic fields surrounding each phase.

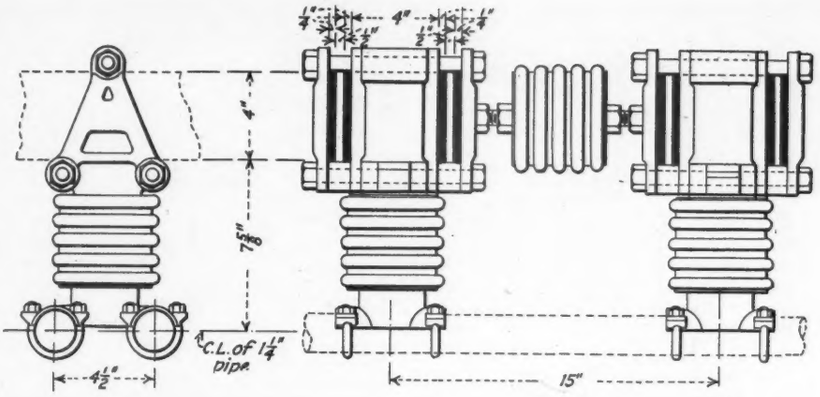


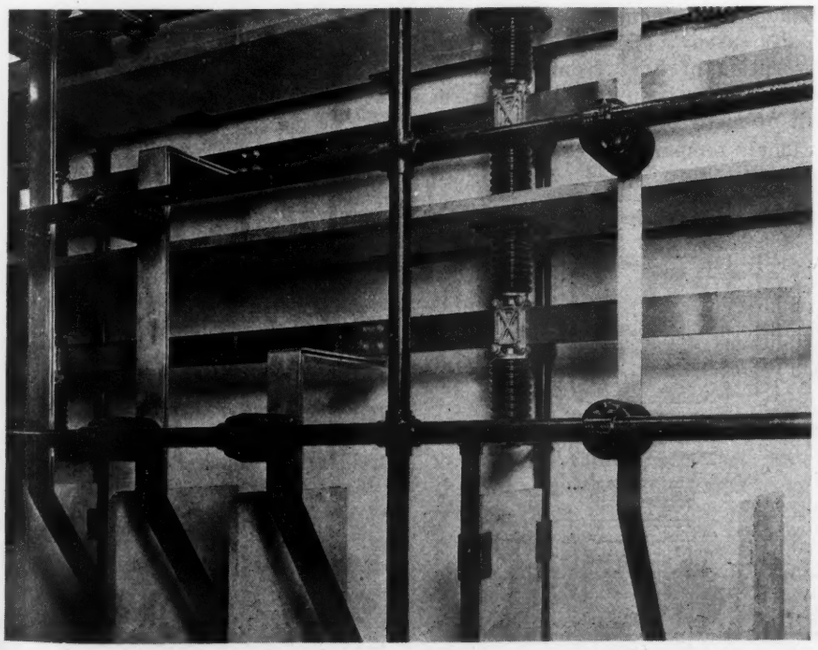
Fig. 7—Special unit-type busbar supports with separators.
The bus is divided into two sections, for handling currents of 2,500 to 4,000 amp.

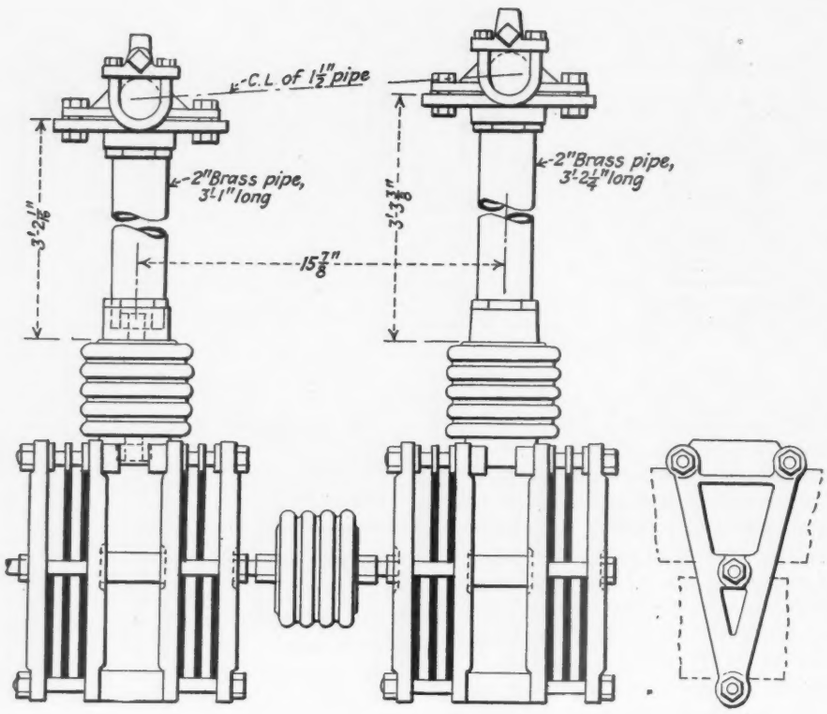
Another condition that has to be provided for is the heating effect of eddy currents induced in adjacent iron or steel parts. For this reason it is customary to use some non-ferrous metal in all parts of the supports where the current exceeds 3,000 amp. This includes the hardware on the insulator unit itself, as well as the clamp bolts and nuts for attaching the conductor to the insulators. As the capacity of the bus is increased, it also becomes necessary to keep it a considerable distance away from the supporting steel or the reinforcing bars, if the support is mounted on concrete. In order to do this, it is customary to mount the supports on brass pipes or structural shapes. The distance necessary between the busbars and steel or iron parts will vary approximately from 16 in. to 3 ft. or more, depending upon the amount of current handled.

It is also possible to neutralize the eddy currents generated in the iron and steel supporting members by surrounding them with a copper short-circuiting loop having approximately 25 per cent of the cross-sectional area of the bus. These loops are mounted directly under the bus and act in a way similar to the short-circuited secondary of a transformer.

Where buses are isolated or mounted so that there is a considerable distance between phases, the so-called proximity effect is not a factor that will affect to any great extent the distribution of current in the bars. However, if the dis-

Fig. 6—This shows an installation of heavy-duty, unit-type supports.





tance between phases becomes too great with a heavy-capacity circuit of considerable length, there will be an inductive drop in the bus. It is, therefore, advisable to keep this distance within 4 or 5 ft., if possible. This is something that will vary with almost every installation, depending upon the maximum current, the operating voltage, and the distance involved.

In a good many cases where it is not practicable to secure wide separation between phases, due to lack of space or other causes, it will be found that the bars of a group that are adjacent to the opposite phase will run considerably hotter than the outer bars of the group. Also, where the bars are placed in the formation shown in Fig. 8, the top bars of the inner group will be somewhat hotter than the lower ones, due to the absorption of heat given off from the lower bars.

Fig. 8—Here is a four-section bus group with special unit-type busbar supports with separators.

This grouping is recommended when currents of 4,000 to 7,500 amp. are to be carried.

If bars are grouped as shown in Fig. 9, the top bars will also have an additional temperature rise, due to decreased ventilation as well as absorption of heat from the inner bars. It has been found as the result of numerous tests, that the additional temperature rise of the inner bars of a group, is due not only to unequal distribution of current in the bus, but also to an inductive effect set up by the field distortion of the adjacent phase or phases.

There are numerous ways of mounting the supports for buses; this is a feature that will vary with each individual location. In the case of isolated-phase construction, they are generally run in concrete-cell structures and when this is done, care must be taken to provide sufficient ventilation so that the heat generated in the buses will be dissipated.

Other means employed consist of structures which may be made of pipe framework or structural steel, although pipe has the advantage, in lighter construction, in that it can be clamped together in almost any shape without the necessity of drilling holes or threading. For heavier buses, where the dead-weight loading is too great for a pipe framework, structural steel consisting of standard shapes may be used. Depending upon local conditions, both the pipe and the structural steel framework may be built up either from the floor or suspended from the steel members of the building framework.

It may be said that, in most cases, greater economies in construction can be effected and better operating conditions secured by keeping the maximum current in buses below 7,500 amp., even though it is necessary to increase the operating voltage in order to do this.

Fig. 9—Special mill-type bus supports with separators.

This arrangement approximates the condition existing when tubular conductors are used.

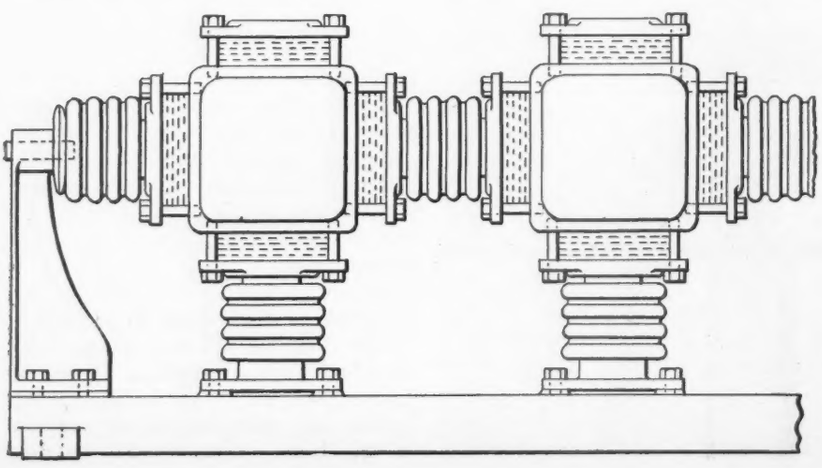


Fig. 10—This shows a three-phase, low-voltage, high-capacity bus assembly plan.

When carrying currents above 7,500 amp. the bus is split into sections with the phases staggered as shown to neutralize the effect of the magnetic fields surrounding each phase.

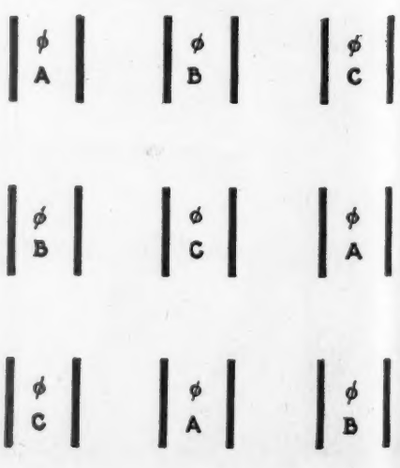



Fig 1—Here are the control panels for four 800-hp. adjustable speed, 600-volt d.c. motors driving the finishing stands of a 12-in. merchant mill in the plant of the Corregan McKinney Steel Co., Cleveland, Ohio.

Steps in the development of

Control for Steel Mill Auxiliaries

By G. E. STACK

Industrial Control Engineering Department, General Electric Co., Schenectady, N. Y.

ONE of the reasons for the wide and extremely successful application of electric motors in the iron and steel industry is to be found in the correspondingly rapid development of suitable control equipment for starting and stopping the motor and, in many instances, regulating its speed. During this period of development there have been many interesting trends and, at times, rather marked differences of opinion and practice.

Looking back, for a moment, the small direct-current motors originally applied on the simpler drives required only a simple form of control for starting and stopping. Either a faceplate dial starter, or the stronger drum switch, sufficed.

The success that attended the first motor applications created a demand for more motors, as well as for motors of larger capacity. The larger motors required control for handling heavier currents. The dial starters were consequently provided with a contactor having a magnetic blowout for making and breaking the motor armature circuit, the dial part being used only to cut the starting resistor in and out of the armature circuit.

The drum switches were also made for greater current capacities and the fingers were provided with magnetic blowouts. These control devices soon became too large and cumbersome, however, for manual operation, especially on drives that required frequent starting and stopping.

The development of magnetic contactors progressed rapidly under these conditions. They were applied first for handling large currents and were well suited for this service. A drum switch having a number of contacts, each designed to handle from 300 to 500 amp. or more, was too large to be operated conveniently by hand, but a small master drum switch sufficiently large to handle the coil circuits of the magnetic contactors, together with a sufficient number of contactors, made a controller combination that was easy to manipulate. These magnetic control equipments could be maintained at a lower cost than any other type of control, and partly for this reason they were gradually applied to smaller motors.

By providing interlocks (auxiliary contacts sometimes called butterflies) on the contactors and wiring the succeeding contactor coil circuit through them, a definite sequence of closing was established. Then, by adding suitable current relays, the successive closing of the contactors could be stopped when the motor current exceeded a predetermined value. This combination of contactors and relays proved very satisfactory as it provided protection for the motor during starting, and became known as current-limit control.

Overload relays provided with suitable, adjustable means for opening the line contactor coil circuits protected the motor from running overloaded. By the use of suitable interlocks undervoltage protection was provided, and thus the motor was prevented from starting up after a voltage failure, until the operator intentionally manipulated the master drum switch or pushbutton.

Magnetic control provides so many protective features for the motor, the driven machine, and the operator, that its use has in the past few years become general, not only on large and small motors in steel mills but in all other manufacturing plants as well. The hand control devices now used are few and relatively simple; therefore this article will deal largely with magnetic control.

Control for D. C. Motors Driving Steel Mill Auxiliaries

Under the classification of auxiliaries are included screwdowns, manipulating fingers and bars, roll tables and other drives requiring frequent starting, stopping and reversing. Series motors or motors with strong series characteristics are generally used and only magnetic control with powerful blowout coils on the contactors will stand up successfully for long periods. The master switches for operating the panels are made small and strong so that one man can operate several without becoming fatigued. Some of the earlier panels consisted of four reversing contactors and a suitable number, four or five, resistor or accelerating contactors. The closing of the contactors was governed by two separately-mounted, current-limit relays that operated alternately.

Later and less complex forms, instead of having separately-mounted relays, had one individual current-limit relay or interlock provided with a series coil for each of the accelerating contactors.

One form of this relay was designed with a small range between the pick-up and drop-out current values. As the relay was wired in series with the main circuit of a contactor, it would open its contacts on the inrush caused by an accelerating contactor closing and cutting out a section of the resistor. The contacts were held open until the motor current dropped to the predetermined value and were then closed, thus energizing the next accelerating contactor.

Another form of this relay, shown in Fig. 2, was mounted directly on the contactors and was called a current-limit interlock. These interlocks were made with both series and shunt coils. Those with shunt coils were usually mounted on the line or reversing contactors, with the shunt coil so connected that it would be energized from the voltage drop across the starting resistor.

The interlocks with series coils were connected so that the motor current flowed through the entire coil until the closing of the contactor on which the particular interlock was mounted. When the contactor closed, the current passed through only a part of the coil, and at the same time the mechanical support of the plunger was removed so that it was supported only magnetically and was free to fall as soon as the current flowing through the half coil decreased to the predetermined value. The plunger carried a contact disk which completed the circuit to the coil of the next accelerating contactor; thus the current was limited to a predetermined value, as each succeeding contactor closed.

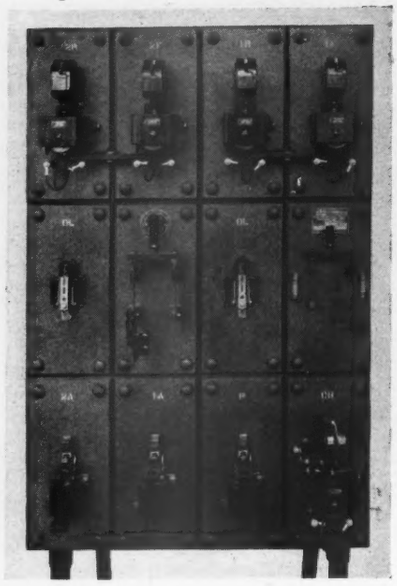


Fig. 2—This control uses current-limit interlocks on the contactors.

The principle of operation is explained on this page. In the unit shown here the forward and reverse line contactors are mounted on the top panels. The line switch, control circuit switch and overload relays are on the center panels. The accelerating contactors and circuit breaker contactor are mounted on the bottom panels.

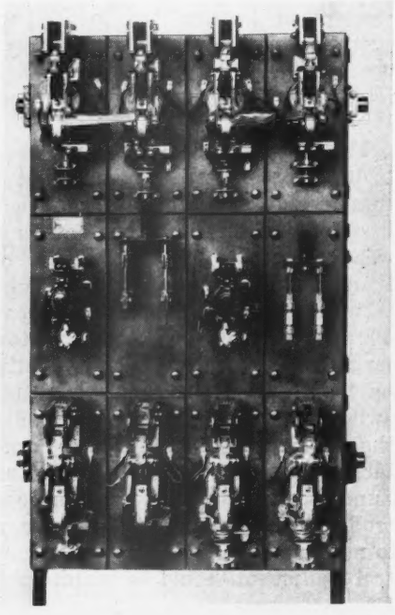


Fig. 3—Series lockout contactors are used on this control, which was designed for a 230-hp., 230-volt, direct-current motor.

The forward and reverse line contactors are carried on the top panels. From left to right on the bottom panels are the accelerating contactors, and the plugging and circuit breaker contactors.

Principles of Series Contactor Equipments

Current-limit interlocks were standard for a number of years and several hundreds are still in operation in steel mills throughout the country. About 16 years ago equipments using series lockout contactors (more briefly called series contactors), shown in Fig. 3, made their appearance. These contactors were made in various forms using slightly different principles for their operation. Each, however, had the characteristic of locking open when a current above a predetermined value was suddenly passed through the series coil, and remaining open until the current decreased to the calibrated value; then it would close and cut out a part of the starting resistor.

It would remain closed and keep the resistor shorted as long as the motor current did not drop below 10 per cent of full-load value. In case it *did* drop out a current somewhat in excess of one-third of the full-load motor current was required to close it. This feature, however, did not prove disadvantageous for steel mill applications, because the running current of the series motors seldom decreased below the drop-out value of the contactors.

When these contactors were used on shunt motors or motors with shunt characteristics, an additional coil was added which held the contactor closed as long as the line contactors were energized. These series-contactor control equipments became very popular, especially for steel mill auxiliary drives requiring only straight starting, stopping and reversing, because the wiring of the panel was so very simple. They did not, however, work out very satisfactorily where speed control was required.

These applications of pure current-

limit control naturally suggested possible refinements; consequently designing engineers felt it was desirable to inject a time interval into the control. The principal objection to current limit was that a different adjustment of current value was advisable for a cold mill, as compared to a warmed-up mill. This quite frequently necessitated changing the current-limit setting every time the mill started up after a long shutdown. It at least required that the contactors be pushed in by hand until the mill loosened up. In the case of a new mill, continual readjustments were necessary until the mill was worn in. When applied to drives with variable load and with the relay adjusted to accelerate the maximum load, the light load would be rushed up to speed, putting the same stresses on the gears and driving machinery as when starting the heavy load.

Again, the progress in motor design had at this time advanced to the point where the motor would stand occasional high peak overloads, which was another argument in favor of time-limit control.

Control using dashpots was tried out for steel mill operation, but all the disadvantages of the dashpot were emphasized. Therefore, the voltage-drop system was developed to meet the conditions imposed.

One form of the voltage-drop system consists of a current-limit action in combination with a time lag, a separate relay being used for each accelerating point. This combination is shown in Fig. 4. The relays have normally closed contacts and are provided with two shunt coils. On starting, the pick-up coils of each relay are first energized simultaneously, thus opening the contacts of all the relays. At the same instant the holding or calibrating coils are shunted across various parts of the starting resistor, thus subjecting them to the drop in voltage across this resistor. As each contactor closes in succession, it short circuits the operating coil of the relay controlling that contactor, and also short circuits the resistor coil of the next relay, leaving it free to function when the line current again decreases to the value corresponding to the desired setting. The time lag is caused by the assistor coil being short-circuited and not open-circuited. Thus a definite time is required for the operation of the relay because of this, even though the voltage on the operating coil falls rapidly to less than the calibration values.

This system, from the engineering standpoint, is nearly ideal for any control involving current limit. It is, however, somewhat more complicated than a straight time-limit system, a form of control that has met with great favor among steel mill electrical engineers.

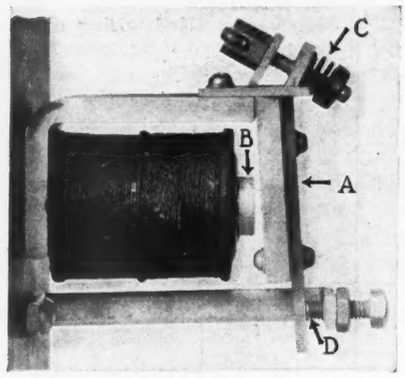
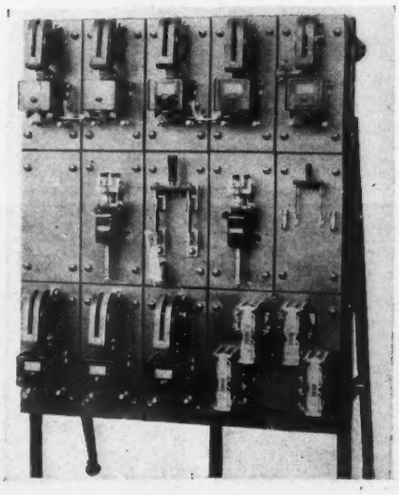


Fig. 5—Here is a magnetic time-limit relay.

When the coil is energized the armature, *A*, is attracted towards the pole, *B*, against the force of the calibrating spring, *C*. This closes the magnetic circuit and opens the contact at *D* in the coil circuit of the accelerating contactor. When the relay coil is de-energized by being short-circuited the armature is free to drop out and close the contact again. However, due to the self-inductance of the short-circuited coil in connection with the heavy magnetic circuit, there is a time delay that holds the armature in and the contacts open for 0.4-1 sec., depending on the setting of the calibrating spring. Adjustment of the time element can be obtained by inserting brass shims between the armature and pole.

Fig. 4—This shows a control that uses the voltage drop principle.

The forward and reverse line contactors are at the top of the board. The lower panels carry the accelerating contactors, at the left, and the accelerating relays. The principle of operation of this type of control is explained in the left-hand column.



Magnetic time limit control has attracted considerable attention as it provides definite time-limit acceleration. A very important feature is the simplicity, both of the operating principle and of the various units that make up a complete control equipment. The whole operation hinges upon the principle of magnetic time-delay, a feature present in the previously mentioned form of voltage-drop control. No complicated system of interlocks or other devices requiring delicate and continual adjustments is necessary to give the requisite timing of the accelerating contactors. As a result, the system is highly reliable in its action over long periods of usage. The individual devices that are combined to make up a complete panel are also of the simplest character.

A vital principle of the magnetic time-limit system rests in the method whereby the proper timing of the accelerating contactors is obtained by means of definite time relays. These relays are of the normally closed type and consist of a coil surrounded by an especially heavy magnetic circuit operated practically at the saturation point. As the effectiveness of the control as a unit depends upon the action of these relays, a description of their construction and operation is given in the caption accompanying Fig. 5.

There are two particular features characterizing the relays that add considerably to the effectiveness and reliability of the control system of which they are a part. The adjustment is practically constant under all conditions and is unaffected by voltage variations, temperature changes, dust, moisture, or gases. Furthermore, the construction and design of the relays themselves are such that the coils of all relays for a given voltage are identical, regardless of the horsepower of the motor to be controlled. As a result, they are interchangeable, which reduces the stock of spare coils to a minimum.

A clear conception of the operation of these relays under actual service conditions can best be given by a description and explanation of some specific types of control equipments of which they form a part.

The operation of the reversing control, a simplified wiring diagram of which is shown in Fig. 6, is substantially as follows: First, assume that the motor is to be started from rest, in the forward direction, and that the line switch has been closed.

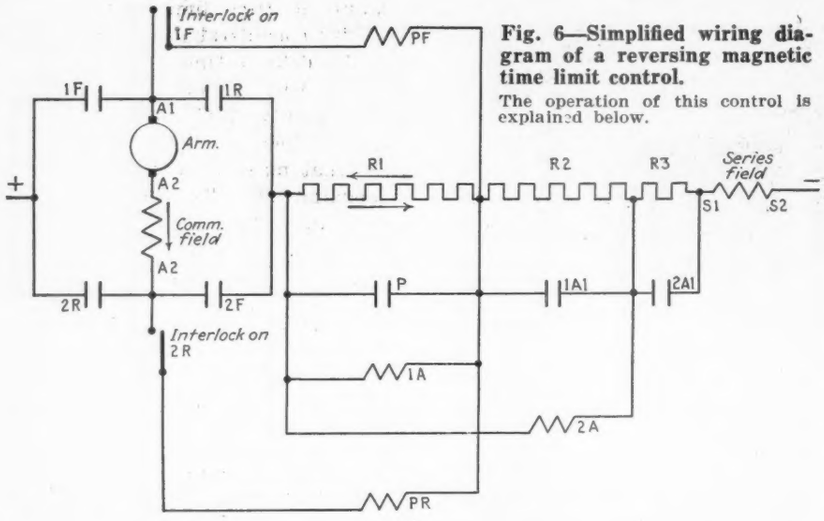


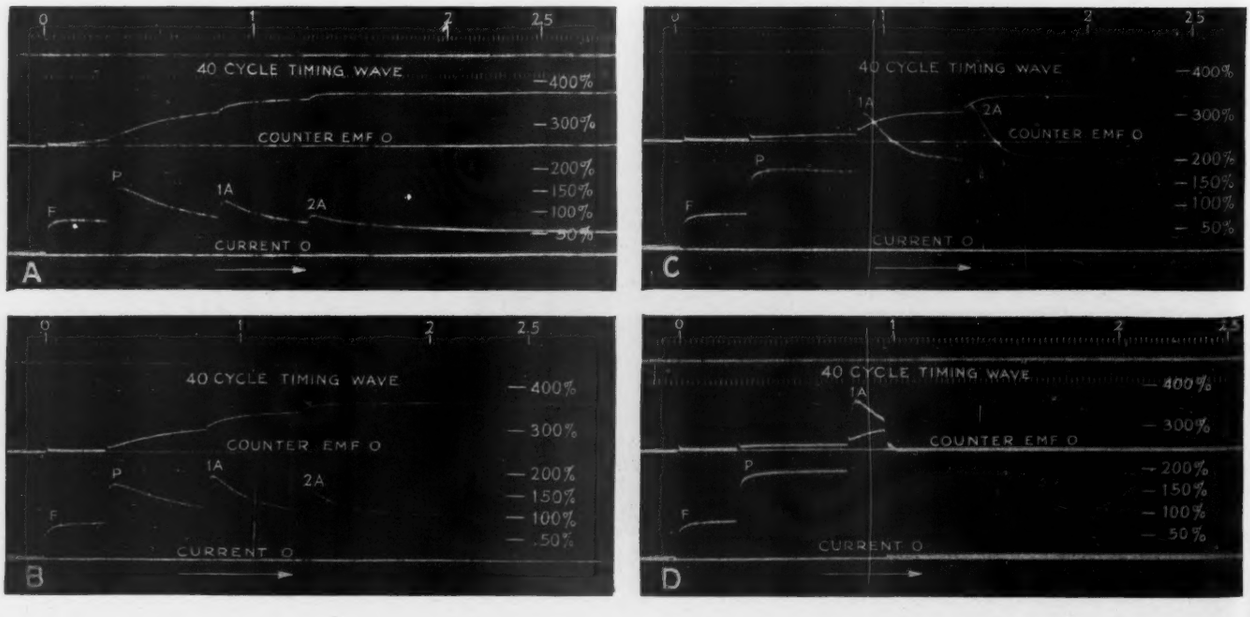
Fig. 6—Simplified wiring diagram of a reversing magnetic time limit control.
The operation of this control is explained below.

When the master switch is moved from the off position to the forward position, the contactors *1F* and *2F* close, allowing current to flow through the motor and the starting resistors *R1*, *R2*, and *R3*. At this point two operations take place simultaneously: a voltage equal to the *IR* drop across resistors *R1* and *R2* is impressed on the coils of accelerating relays *1A* and *2A* which immediately open their contacts, and an interlock on contactor *1F* closes the coil circuit of the counter-emf. relay *PF*. As the *IR* drop across resistor *R1* and either the *IR* drop or the counter-emf. in the motor armature are in the same direction, the sum of the former and either one of the two latter is enough to energize the relay coil, causing it to pick up its armature and close its contacts. Only a small percentage of the relay closing voltage is enough to hold its contacts closed; so either the *IR* drop across the motor armature or the increasing counter-emf. will hold it closed after resistance *R1* has been shorted out.

Closing of the relay contacts completes the coil circuit of the plugging contactor *P*, which closes, short-circuiting resistor *R1* and the coil of the accelerating relay *1A*. After a definite time delay the armature of this relay lets go, and closes its contacts, completing the circuit of the actuating coil of the accelerating contactor *1A1* which closes, cutting out resistance *R2*. Closing of the contactor *1A1* short-circuits the coil of accelerating relay *2A1* which, after a definite time, releases its armature, thus closing accelerating contactor *2A1* and cutting out the last of the resistance in the motor armature.

The action of the control when the motor is reversed, or plugged, while practically the same so far as the physical sequence is concerned, involves some difference in the electrical phenomena which bring about this sequence. When the master controller is moved to the off position, the accelerating, plugging and forward contactors will open, disconnecting the motor from the line. When the switch is moved to the reverse position, contactors *1R* and *2R* will close, admitting current to the motor in the reverse direction. Relays *1A* and *2A* are energized and open their contacts. An interlock on *2R* closes the coil circuit of the counter-emf. relay *PR*, but since, at the instant of closing, the counter-emf. of the motor is in the opposite direction to the *IR* drop across the resistor, the two tend to neutralize each other, and relay *PR* will not

Fig. 7—These oscillograms show the conditions existing during acceleration of a motor with magnetic time limit control.
The upper curve is a 40-cycle timing wave calibrated in seconds for convenience in determining the time consumed in the operation of the equipment. The middle curve represents the counter-emf. of the motor armature and the bottom curve, the armature current. The figures at the right indicate the percentage of full-load current. The peaks marked *F*, *P*, *1A*, and *2A*, show the point of operation of the forward and plugging contactors and the two accelerating contactors, respectively. Acceleration under light load is shown in oscillogram *A*. The total time from rest to full speed is about 1.3 sec. Acceleration under 100 per cent load is shown in *B*, where the time required to attain full speed is about 1.4 sec. In *C*, acceleration under 100 per cent overload is shown. Full speed is reached in about 1.8 sec., and the current peaks bear about the same relation to the load as in oscillogram *B*. Acceleration of a stalled motor is shown in *D*. The overload relay opened the circuit before contactor *2A* closed.



close its contacts. As the speed of the motor decreases, its counter-emf. decreases and the voltage impressed on the coil of relay *PR* gradually increases until, at about the instant when the motor armature comes to rest, this relay closes its contacts, energizing the coil of the plugging contactor, *P*, which closes, cutting out resistor *R1* and short-circuiting the coil of relay *1A*. The remainder of the sequence is similar to that described in the case of starting from rest.

An analysis of this operation shows that, although the motor is thoroughly safeguarded during starting from rest or in plugging, no element is present that will unnecessarily limit the speed with which it responds to the movement of the controller. As far as the control itself is concerned, the two operations are absolutely independent. For example, on starting from rest the plugging resistance is cut out of the circuit immediately, whereas in plugging, it is kept in until the motor has come to rest, limiting the current during plugging to a safe value.

These points are brought out in the accompanying oscillograms, Figs. 7 and 8. As the oscillograms in Figs. 7 and 8 represent varying phases of two distinctly different operations of the control, they will be discussed separately. All of these records were, however, obtained on the same equipment and without any alteration in the adjustments of the control apparatus.

In the first group, Figs. 7*A*, *B* and *C* which covers acceleration from rest under varying load conditions, it will be noted that, in spite of the increase in load, the total time from zero to full speed does not increase in anything like proportion to the load, and that the speed of the motor, as indicated by the counter-emf. curve, shows a smooth and rapid acceleration under all conditions. Furthermore, as the plugging contactor, designated as *P* operates about 0.3 sec., after contactor *F* to short out the plugging resistance, no delay is caused in the acceleration. It will also be noted that, although the current peaks are naturally higher for normal, Fig. 7*B*, and 100 per cent overload, Fig. 7*C*, they are never excessive and in every case bear about the same relation to the load.

Fig. 7*D* represents an attempt to accelerate a stalled motor from rest. It will be noted that the overload relay operated so rapidly that the motor was cut out of the circuit even before the second accelerating contactor could close.

In the case of the second group, Figs. 8*A*, *B* and *C*, which covers plugging reverse under the same conditions, the records show that although the time taken for the motor to come to rest from the forward direction varies with the load, the plugging contactor *P* never closes before the motor speed reaches practically zero. In other words the protection provided by the plugging resistor is not removed until the need for it has ceased. At the same time no delay is caused by leaving the resistance in the circuits longer than necessary.

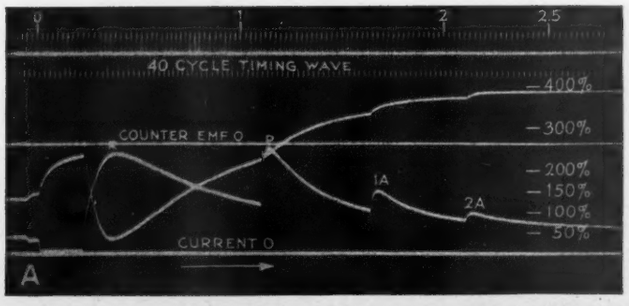
In inductive time limit control a transformer arrangement is used for inducing a flow of current in lockout coils. In addition to the usual shunt closing coil, each accelerating contactor is provided with a second shunt lockout coil that acts on the tail piece of the armature. The air gap of the magnetic circuit for this lockout coil is adjustable by means of shims underneath the coil and by an air gap adjustment which, when once determined, can be definitely set. The solid core transformer on the rear of the control panel is equipped with shunt coils. The number of coils on the transformer is one more than the number of accelerating contactors. The mutual inductance between the coils on this transformer is utilized to provide currents that control the holding-out period of the accelerating contactors.

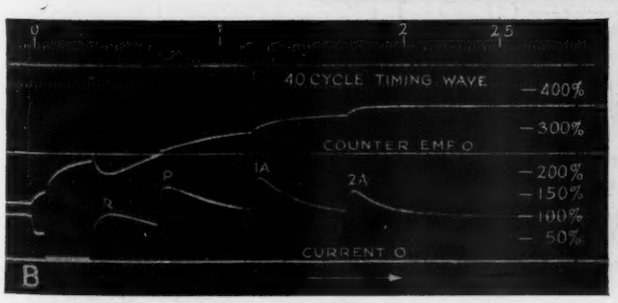
As the holding-out coil on each accelerating contactor is connected to its respective transformer coil, and is of relatively low resistance, these coils act as a low-resistance load, each connected to its own transformer winding. The transformer windings are mounted on a common core, so that they all bear a definite relation to each other. Any reversal of or change in the transformer flux will cause an induced current in the short-circuited transformer coil. This sets up an electromotive force that at first tends to oppose the building up of the flux and, after the change in flux has ceased, causes a current to flow between the holding-out coil on the contactor and the transformer coil. This current is of a transient nature and tends to maintain the change of flux.

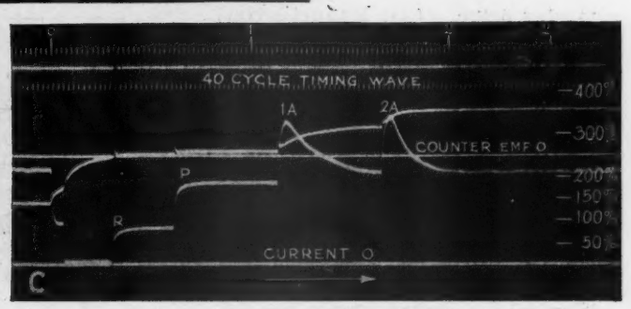
The diagram in Fig. 9 shows, in simplified form, the relation of the

Fig. 8—Conditions under plugging reversing of motor with magnetic time limit control.

The curves and markings at current peaks are the same as explained for Fig. 7. Plugging at light load is shown at *A*, which indicates that the time from full speed forward to full speed reverse is about 2.25 sec. In *B* it is seen that under 100 per cent load the time between full speed forward and full speed reverse is about 1.9 sec. When plugged at 100 per cent overload, *C*, the time is about 1.95 sec.







transformer coils to one another, and their connections to the holding-out coil on the accelerating contacts.

Transformer coil *1* controls the plugging switch. It is so connected that in starting from rest the plugging switch has practically no time lag, but, in plugging, the closing of the plugging contactor is delayed until the motor has come to rest and is ready to reverse. Transformer coils *3*, *4* and *5* are each connected across steps of the accelerating resistor and so have a definite voltage drop across them when the motor circuit is first closed. Coils *3* and *5* are accumulative and coil *4* is bucking.

In starting from rest a very low voltage is impressed on transformer coil *1* and it, therefore, has no effect. Coil *2* is simply short-circuited on the lockout coil of the first accelerating contactor. Because of the magnetic flux set up in the transformer core by coils *3* and *5* overcoming the bucking effect of transformer coil *4*, a current is set up in coil *2*, which holds out the first accelerating contactor. This holding-out period depends upon the design of the transformer and lockout coils, and the adjustment of the air gap on the contactor varies the closing current on the switch and provides the necessary accelerating regulation. When this first accelerating contactor closes, transformer coil *3* is short-circuited, causing a change in flux in the transformer core. This sets up a transient current in coil *3*, which controls the holding-out period on the second accelerating contactor, *3R*, in exactly the same manner as for the first accelerating contactor. The commutation of the successive resistance steps and the changes in transformer flux control the remaining accelerating contactors in the same manner.

From the foregoing it will be seen that the steps in the evolution of control for steel mill auxiliaries have been, (1), manual operation in three forms: dial switches, drum switches and magnetic switches with a master drum. (2), Magnetic control employing automatic current limit. (3), Magnetic current limit with time-delay feature. (4), Magnetic time limit with current limit only on the plugging point.

It is difficult to predict the next step, but it seems likely that it may be straight time delay, or some still simpler method of obtaining this effect.

Control for electric cranes has followed the same general trends as the control for steel mill auxiliaries. To the casual observer this may not appear true, because there are so many cranes in service that are fitted with drum switches and Dinkey controllers for handling the motor current direct.

The crane builders have made a practice of manufacturing and installing cranes complete, including the electrical equipment. In order to quote a competitive price, some of them unfortunately have included the least expensive form of control. The ultimate customer whose buying is governed by price considerations may receive a crane fitted with either drum switches or Dinkey controllers, unless he specifies that magnetic control is desired. The drum switches supplied are carefully designed and provide all the operating characteristics for lowering and hoisting at the various speeds in a satisfactory manner, but the life of a drum switch is very short compared with the life of magnetic equipment. Some engineers have reported, on the basis of very carefully kept records, that it costs in some cases as much as twenty times as much to maintain a drum switch, as it does to maintain a magnetic panel.

The magnetic time control as applied to cranes has proved superior to the current-limit type, especially on such applications as ladle and charging cranes, where it has been the rule to supply current-limit control. Definite time acceleration of moving parts subjected to extreme load conditions, such as crane hooks, permits the operator to judge the travel of the motion better and more accurately.

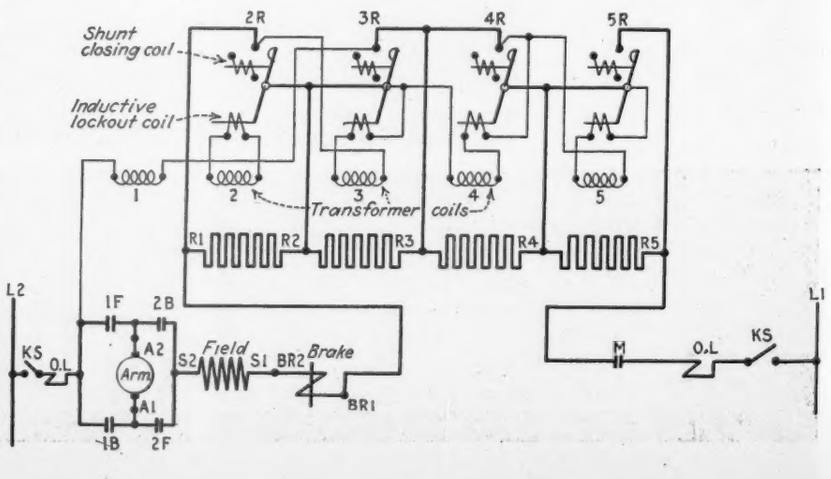
The application of a.c. motors to steel mill auxiliaries has never been on such a large scale as in the case of d.c. motors. Therefore, the demand for control has not been large and as it did not receive as much attention, very few advances have been made. The same type of control used on the main mill drives has been applied to auxiliary drives.

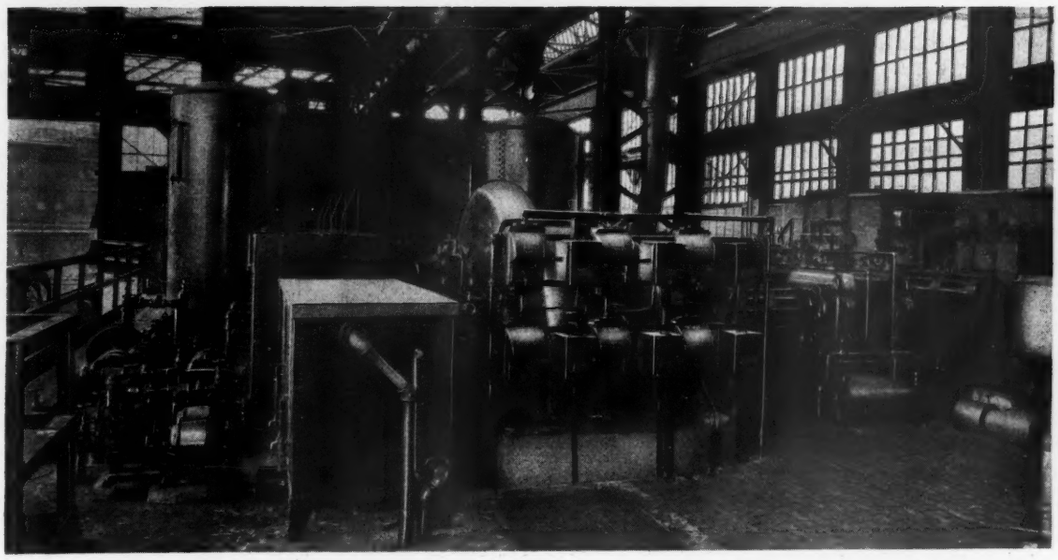
One form of automatic magnetic panel consisted of double- or triple-pole contactors controlled by a pair of current-limit relays, the relays alternately governing the closing of the accelerating contactors. Each contactor had a three-circuit auxiliary interlock that automatically transferred the contactor coil circuits to the proper relay. One relay governed contactors *1*, *3*, *5*, etc., and the other relay governed contactors *2*, *4*, *6*, etc.

Another form of magnetic panel had current interlocks attached directly to the accelerating contactors. These interlocks were operated from the secondary current of the motor and were designed to function on a certain value of current, regardless of frequency. This was necessary because the frequency of the rotor circuit varies from line frequency to nearly zero.

The success attained by the time-limit, d.c. control is having its effect on alternating current to the extent that a few equipments having a time-limit interlock for each accelerating contactor are now being installed. The interlock consists of a simple set of gears, an electrical contact and a pendulum and clock-work escapement. The closing of the contactor compresses a spring that forces the interlock contacts to close. The time element before closing depends upon the length of the pendulum and the amount of travel permitted on the rack.

Fig. 9—Schematic connection diagram of inductive time limit control.





This is an oil circulating and filtering system in a steel mill. The tank in the left foreground is the filter for oil from the bearings; the tank behind it is for oil circulated through the gears. The large round tanks are for oil storage. The circulating pumps for this Bowser system are at the left.

Reclamation of Lubricating and Insulating Oils

By FRANK E. GOODING
Associate Editor, Industrial Engineer

MANY industrial operating men look upon oil purifying or reconditioning devices as being primarily a means of conserving oil. The economy of such apparatus, however, depends not so much on the actual saving of oil as upon the protection given to the units served. In cases where the equipment is wrecked or seriously damaged because of faulty lubrication it cannot be put back into service with the money saved during many years of false economy in the use of lubricants. Again, when a transformer burns out, the money lost would pay for filling it a good many times with new oil.

Problems in oil reclamation, purification, or reconditioning are becoming of increasing importance in industrial plants. Until within the past few years, most of this work has been directed toward the treatment of lubricating oils, particularly from engines.

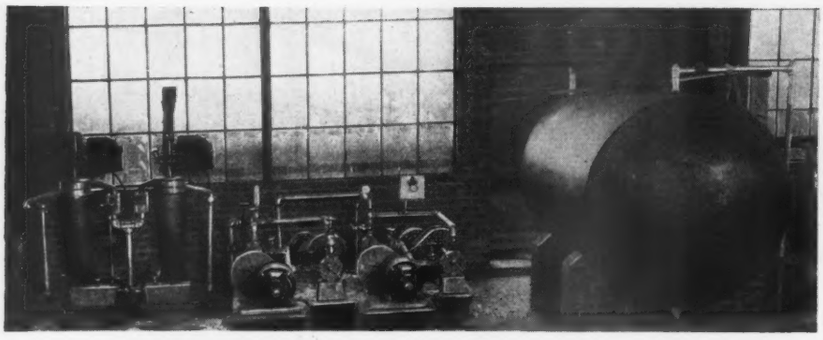
Within recent years the use and re-use of both lubricating, transformer and switch oils has increased until it has become an important consideration in connection with industrial plants containing units of large size or a number of units which would give a sufficient quantity of oil to be worth while saving and treating. In addition, many concerns have adopted a policy of treating all new oil before it is placed in storage to be sure that it is free from water, and rust or dirt that may have become loosened from the inside of the container. In this article some of the problems involved in such treatment and the equipment used, will be discussed.

Contamination of lubricating oil is due to dust from the atmosphere or created in the process, to metallic particles worn from the bearings, gear teeth, or other sliding or rolling surfaces in contact, to foreign particles such as sand or scale loosened from the inside of the gear case, or oil reservoir, and to water which may come from either the atmosphere or be formed in the process.

The method of reclamation or reconditioning must be such that the impurities are removed without affecting the composition of the oil. There are a number of methods of doing this and a wide variety of types of equipment used. In general, lubricating oils may be reclaimed or reconditioned by any one of three common methods, or by a combination of these methods. These methods involve: precipitation and filtration, separation of impurities by centrifugal force, and removal of impurities by coagulating them by the use of special chemicals.

The reconditioning of lubricating oils by precipitation is based on the difference in the specific gravities of oil, water, and the solid impurities. Oil will float on water and if the oil is passed through the water a certain amount of the solids will separate and settle to the bottom of the tank or vessel used. However, precipitation would ordinarily require too much time; also, the oil passes through the water in the form of drops or globules, each of which might contain some of the foreign particles that have a specific gravity very close to that of the oil.

Natural precipitation, which would result from leaving the lubricant



Centrifugal oil purifiers at the Lukens Steel Co.

These two No. 6 Sharples centrifugal oil purifiers continuously recondition and purify the 2,500 gal. of extra-heavy lubricating oil circulated to bearings, pinions, and so on, at the rate of 30 gal. per min. This amount of oil supplies an 84-in. tandem plate mill and a 3,000-hp. G.E. motor-generator set, together with one 2,500-hp. and one 1,200-hp. G.E. driving motor.

stand for a time, would be very slow, especially with oils of heavy viscosity. For this reason, viscosity is frequently reduced by heating the oil, but care must be taken to see that it is not continually agitated which will prevent the natural precipitation of foreign particles.

Some method of filtering out foreign particles, which do not settle readily, is generally used in connection with precipitation equipment. The precipitation chamber is relied upon only to remove the heavier impurities. Filters, in general, are of two types: those containing screens which may be removed and cleaned, and those in which a loose or porous filtering material, such as waste, bone black, Fuller's earth, or other similar materials is used.

The following description of a Nugent filter of the cabinet type, shown in an accompanying illustration, indicates the operation as well as the general construction of one of these units. This is a triple-bag, cabinet-type unit and is designed to separate all foreign matter, including water, from the oil. The top part of the cabinet is divided into three sections; the first section is the dumping tray. The oil then passes through 2 in. of washable filtering material that removes most of the heavy foreign matter but not the water.

The oil then flows into the second or precipitating chamber where the water settles to the bottom and is drawn out. The oil, now free from water, overflows through a pipe into the filtering bags which occupy the third and lowest chamber and extend into the storage reservoir below. Three thicknesses of filtering cloth remove the dust and fine dirt and the oil then passes into the storage chamber, from which it is drawn as used.

Provision is made in this unit for heating the oil in the dumping chamber by means of either steam coils or by electricity. This action facilitates the separation of the foreign matter by reducing the viscosity of the oil. The bags may be removed and cleaned at intervals depending upon the amount of contamination. It is very important that filter bags or any other filter medium be of such nature that it can be cleaned, or else be inexpensive enough to permit throwing away.

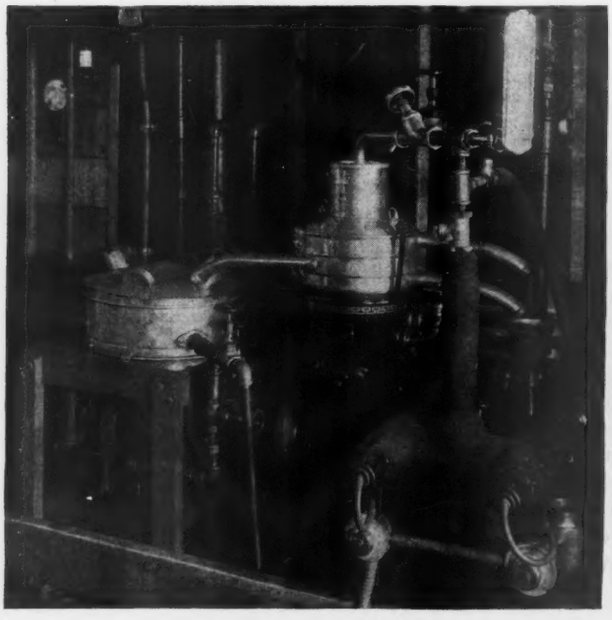
These filters are made of closely woven material. Screens of cloth with uneven mesh or texture do not give good separation. Also, the rate at which the oil passes through the filter determines to a large extent the quality of oil after treatment. If the oil is forced through too rapidly it is likely to carry some impurities with it. Cabinet-type filters, such as described, are frequently used for the storage of reconditioned oil as well as for the cleansing process.

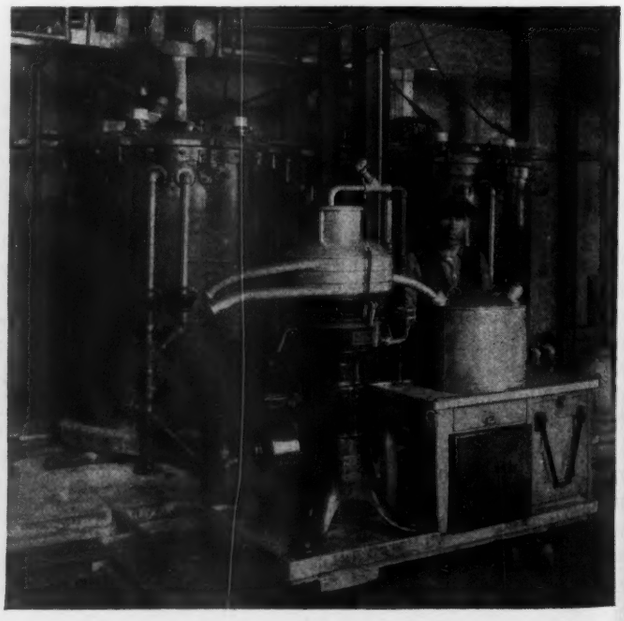
Another type of combination filter and storage tank with the addition of a measuring pump is shown in one of the other illustrations. This is Bowser equipment and is intended for use in industrial plants for the reclamation of oil taken from gear cases, and speed-reducer housings, and bearings. This used oil is poured into a dirty-oil section and passes through the filter into storage.

With any method of reclaiming

Two installations of DeLaval centrifugal separators.

The installation at the left is in the mill of the Long-Bell Lumber Co., Longview, Wash., and is used to recondition the lubricating oil. The installation shown at the right is a portable centrifugal unit handling transformer oils in a Canadian paper mill.

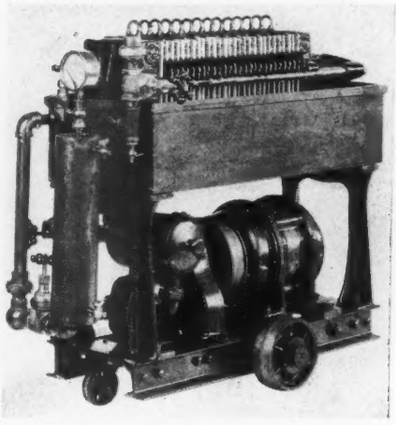




oil it is always best to keep the various grades and types of oil separate. This always assures a more uniform product and more reliable quality. It is especially desirable that blended and animal oils not be mixed in with straight mineral oils.

The method of reconditioning oils by coagulation very frequently combines with it some method of precipitation and filtration. The additional step consists in adding a special coagulant and the entire amount of oil, water, and coagulent is agitated for a short time. This may be done either mechanically or by means of compressed air. After allowing this mixture to settle for a sufficient period the oil and water naturally separate with a layer of sludge between which is made up of the coagulant and the impurities. If the mixture is heated the process is speeded up accordingly. In such equipment provision is usually made to drain off the water and sludge and allow the oil to overflow at the top into storage or through some filtering medium. Equipment using coagulants is generally of a batch type instead of being continuous as the precipitation and filtration methods previously described. The batch type equipment is so called because a quantity or batch of oil is treated as a unit, instead of adding small quantities and withdrawing as desired. The oil must be handled in quantities because it requires time for the coagulated oil to settle and separate after the mixing process.

Because of the rapidity and ease of handling large quantities of oil, centrifugal separators are very widely used for the clarification of lubricating and other oils. The separation is accomplished by the application of centrifugal force which separates the oil from the impurities, due to their difference in specific gravity. Heavy oils are usually heated before treatment by electric heaters or steam coils.



Portable unit for reconditioning transformer and other insulating oils.

This is a General Electric Type FP-10 oil drier and blotter filter press with air bell for testing suction piping. This device is also frequently used in connection with a De Laval centrifugal separator.

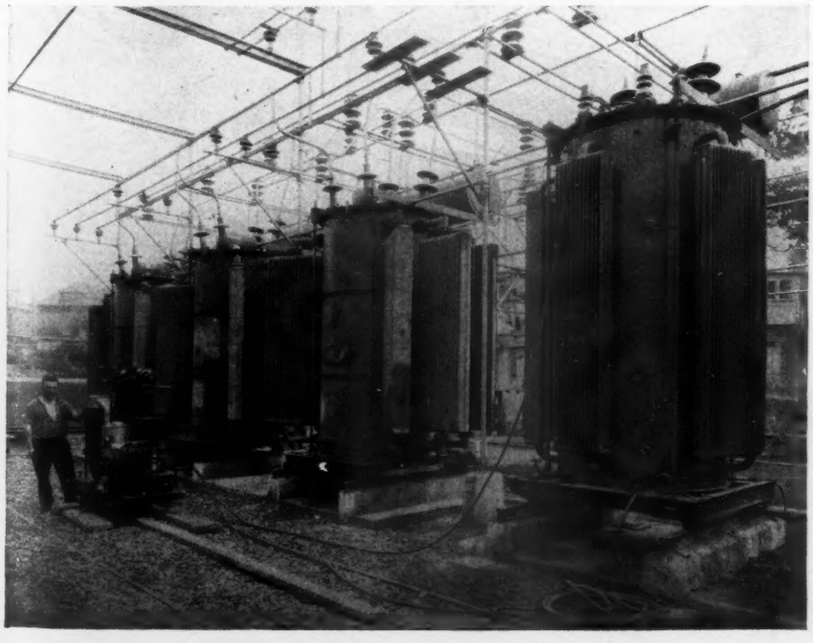
With the increasing use of the circulation method of lubrication, in which a quantity of the lubricant is circulated continuously through the bearings, industrial men have found it necessary to include some of these methods of reconditioning either as a part of the circulating system or as an adjunct to it. This is quite common in connection with turbines and turbine-driven generator sets, motor-generator sets, gear housings, particularly in some of the more modern steel mills, paper mill bearings, especially on the calendar rolls, and other units. The amount and frequency of the reconditioning as well as the method used depends to a large extent upon the operating conditions. Frequently it is also necessary to add a cooling system to bring the temperature of the oil down to normal.

When the oil is badly contaminated or where the requirements of the operating conditions are such as to necessitate absolute freedom from contamination, the oil is treated continuously in that it all passes through the clarifying equipment and is reconditioned before it is used again. This method has its limitations in that practically all methods of reconditioning, except by centrifugal separation, require considerable time. In any case, equipment must be provided which will have a capacity equal to the circulation. Also, for large units the amount of oil handled would be considerable and the equipment necessary to purify it would be expensive.

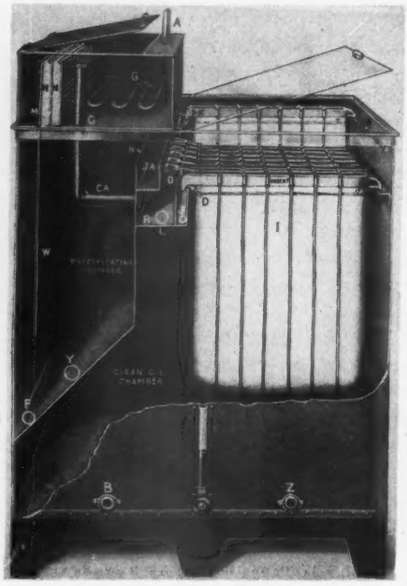
As it is seldom necessary to purify the oil at each pass, the more common practice is to have a definite percentage of the oil pass through the reconditioning equipment continuously and the remainder recirculated. In practically all circulating systems the oil is discharged into and drawn from a reservoir. It is best to withdraw the oil for treatment from the bottom of this, in that the lower strata would naturally contain most of the precipitated materials and the water, or to have a bypass from the pipe line carrying the used oil.

The amount of oil bypassed for reconditioning depends, of course, upon the amount of contamination. Ordinarily, bypassing 10 to 20 per cent is sufficient. Frequently, in such systems, centrifugal separators are placed in this bypass line and operate continuously. Most of the types of equipment for clarifying the oil, such as those employing the filtration or the filtration and precipitation methods, may be used in connection with a continuous bypass.

The batch method of clarification of oil may be used by withdrawing



Here the oil in the tank of a 1,665-kva. transformer is being circulated through the centrifugal separator of a Sharples portable unit.



One of the Nugent lubricating oil filters.

The dirty oil and water enter the filter through pipe *A*, or may be poured in by lifting the lid. The oil then passes over the steam coils *G* (electric heaters may be used if preferred), through the filtering material *H*, and down through the holes *M* back of the baffle plate *W*. The water is removed at *Y* and the oil flows over the weir *N* into trough *JA* and enters the filter bags *I* through the pivotal drips *O*. The oil outlet is through *B*. The filter bags may be removed, cleaned by washing, and replaced.

a definite quantity at a time, cleaning it, putting it back into circulation, and then drawing another batch. This, however, is an intermittent cleaning operation rather than a continuous process.

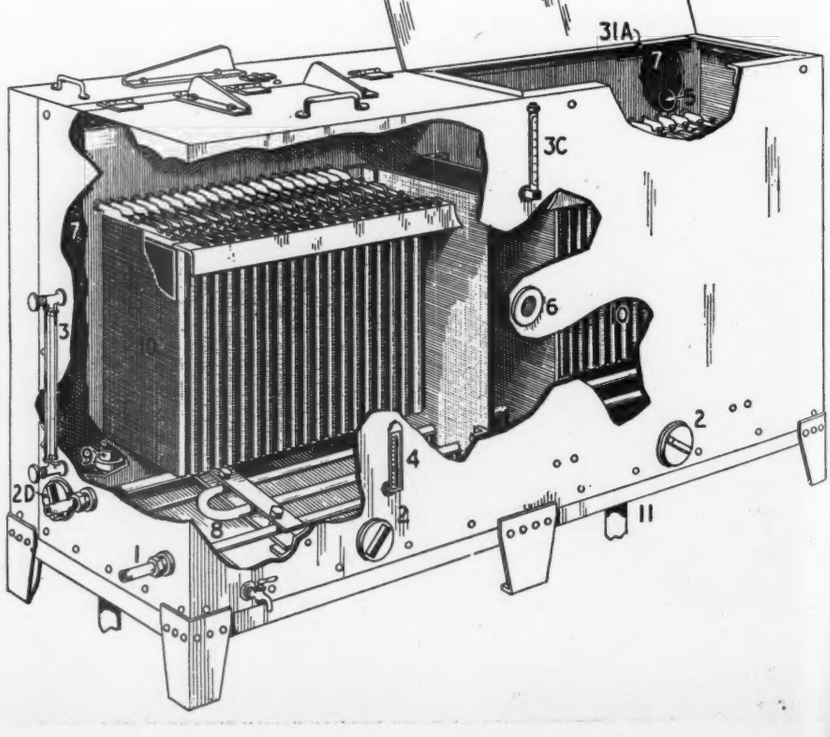
The batch method of treatment is usually used in connection with the periodic emptying of the entire system, reconditioning of the oil, and replacing it in circulation or in storage. One of the handicaps of this system is that the equipment must be shut down to remove the old oil and replace it with fresh oil. Also, the same amount of oil must be kept in storage unless the equipment is to be shut down for the time required for the reconditioning of the oil. Another of the drawbacks is that the oil may be permitted to go too long between reconditioning periods and become filled with impurities which might have a serious effect upon the bearings. Coagulants, in connection with filters and precipitation, are often used with the so-called batch method of reclaiming oils.

Development work has practically been completed on an entirely new process of reclaiming lubricating oil. This process, which was developed by the General Electric Co. in its laboratories will be licensed for manufacture and distribution by The Hilliard Corporation, Elmira, N. Y. Briefly, the method of reclamation consists of three steps: Particles of dirt and abrasive material are separated from the oil by means of a chemical treatment in the first step. This is followed by passing the oil over a tank of water in which these foreign particles are precipitated. The third step consists of rectifying the oil by passing it over electrically-heated plates, automatically controlled at the proper temperature, which remove the water, gasoline and any other objectionable diluents that may be present.

It is stated that this process is practically automatic and requires very little labor or attention. The heat of the rectifying plates as well as the temperature within the machine, are automatically controlled. Although this equipment has not been definitely placed on the market, the machine incorporating the process has been under operation in the laboratory of the General Electric Co. for more than 18 months.

Details of one type of filter used in steel mill service.

This cut-away view of a Bowser outfit shows the filters and settling tanks. The sloping bottom aids in the removal of the sludge and other precipitated matter.



In large industrial plants receiving energy from high-tension lines, proper dehydration of the oil used in transformers and oil switches is of vital importance. The losses resulting from the failure of a bank of transformers, or even of a single unit, are out of all proportion to the cost of insuring against such danger, which is frequently directly due to the continued use of an insulating oil containing moisture, sludge, carbon, or other foreign material.

A good grade of insulating oil forms one of the most satisfactory insulating mediums known, but it suffers deterioration in time, both from the absorption of moisture and the accumulation of dirt and carbon in suspension. Whenever transformer or switch oils are exposed to the atmosphere, a small amount of moisture will be absorbed unless the temperature conditions are just right. From the nature of their service, oils for high-tension switches, circuit breakers and similar apparatus, also accumulate particles of carbon and metal.

The presence of even a small amount of moisture in the oil reduces the dielectric strength. The same is true of particles of carbon, dirt, or other suspended matter,

which, in addition, form undesirable deposits, so that it is necessary, in order to obtain the best service, to employ some method of cleaning and dehydrating the oil from time to time.

Periodic inspection and tests of insulating oil and the dehydrating and purifying of oil that has accumulated moisture or sediment should not be neglected by operators. This is recognized by all who have had experience in the operation of equipment that depends upon insulating oil. Where oil maintenance is systematic, failures of apparatus from burnouts with consequent interruption of service, are minimized, invariably resulting in economy in the use of oil. This is an incidental, but important, advantage.

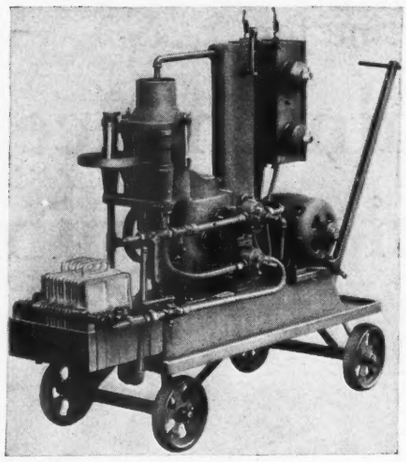
Even new oil should be filtered before being used, to remove any particles of iron rust, scale, or dirt, that may have been detached from the containing vessel during shipment, or moisture accidentally taken up by the oil during handling.

The question of how to remove the impurities from insulating oils has been a serious problem as the clarification of transformer and switch oils presents a somewhat different problem from that in connection with lubricating oils. The consideration of first importance is the removal of all water as well as any sludge and foreign material that may have gotten into the oil. Centrifugal separators and blotter filters, with or without precipitation chambers, are the two types of equipment most commonly used with insulating oils.

In the blotter filter process the oil passes through special blotter or filter papers which absorb the water and also collect any foreign material. Blotters, as soon as they become wet, permit the water to pass through and so must be watched carefully if much moisture is present.

Switch oils offer the additional problem of the removal of the finely divided carbon particles resulting from the quenching of the arc at the time the current is broken.

In the Sharples batch process for

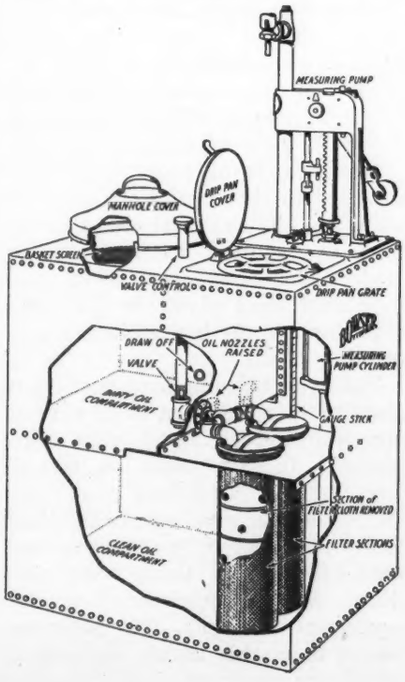


Portable continuous centrifugal oil separator with filter press.

This Hydroil unit consists of a centrifugal separator of the bowl type, together with its pump, motor, immersion electric heaters, and filter press, mounted on a truck. The centrifugal separator only is used on lubricating oils. Insulating oils are passed first through the centrifugal separator which removes all water. Finely divided particles in switch oils are removed in the filter press. The capacity of this unit is 100 gal. per hr.

treatment of insulating oils two reagents are added to the contaminated oils. After the first treatment the oil is passed through a centrifugal separator to remove the water and emulsion containing the impurities. The oil is then given a second treatment and again passed through the separator. Either one or two separators may be used according to the arrangement of the tanks and piping. A typical arrangement using two separators is shown in an accompanying sketch.

The Hydroil unit combines the centrifugal separator and the blotter press for use in the clarification of switch oils. For transformer oils the centrifugal separator is used alone. The switch oil first passes through the centrifugal separator which removes the water and practically all of the other impurities. It then passes through the blotter filter,



Combination filtering and storage unit for comparatively small quantities of oil.

This Bowser unit receives the dirty oil through a basket screen in the dirty-oil compartment. From this it passes through the filters into the clean-oil compartment. The unit will hold 13½ gal. of dirty oil and 30 gal. of clean oil. When bearings, gear housings, or other oil reservoirs are emptied, the oil is poured into this unit and fresh oil drawn out to refill the oil containers.

which has a much longer useful life because the water has already been removed, and so the papers can be used longer because they remove only the very fine carbon and copper particles which were too minute to be separated centrifugally.

The De Laval centrifugal separator is also used in many cases in connection with a General Electric blotter filter.

In the dehydration of transformer oils a commonly used method is to connect the centrifugal separator to the transformer and circulate the oil through the separator and back into the transformer. The quantity passed through the separator should be sufficiently greater than the capacity of the transformer to insure that all the oil has passed through and been clarified.

If desired, however, the transformer can be emptied into a storage tank, the oil purified, and either placed back into the transformer or into storage. This is the process commonly followed when the transformer case is emptied for cleaning or inspection, or for repairs. The frequency of treatment depends upon the conditions under which the electrical equipment operates.

The ever-increasing tendency to use straight mineral oils in the lubrication of all types of steel mill drives and other applications has been an important influence in insuring industrial engineers that the quailty of the oil after reconditioning would be such that it could be used with comparative safety.

EDITOR'S NOTE: Acknowledgment is made to the following companies for illustrations and information used in the preparation of this article: Bousman Mfg. Co., Grand Rapids, Mich.; S. F. Bowser & Co., Fort Wayne, Ind.; The Burt Mfg. Co., Akron, Ohio; The De Laval Separator Co., New York, N. Y.; DeLavergne Machine Co., New York, N. Y.; The Elliott Co., Jeanette, Pa.; Famous Filter Co., St. Louis, Mo.; General Electric Co., Schenectady, N. Y.; Hilliard Corp., Elmira, N. Y.; Hydroil Sales Corp., Lebanon, Ind.; Wm. W. Nugent & Co., Chicago, Ill.; Sharples Specialty Co., New York, N. Y., and Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Organization and routine for

Maintenance of Electrical Equipment

in a small plant

Byproduct coke plant with the Koppers ovens and some of the coal-handling equipment in the plant of the Trumbull-Cliffs Furnace Co.

By O. C. CALLOW

Chief Electrician, The Trumbull-Cliffs Furnace Co., Warren, Ohio

IN THESE days of close competition and high labor costs, a careful study of each department of an industrial plant is necessary from time to time in order to determine whether it is operating on the most efficient basis possible. A study of this character may well be extended to include the maintenance department of the plant. When such an investigation is being made several considerations must be kept in mind in determining the efficiency with which the work is handled. One of these considerations relates to the number of men required. This will depend on:

(1) Type of equipment.

(2) General condition and age.

(3) Importance of continuous operation.

(4) Number of hours plant runs continuously.

(5) How well the plant has been maintained.

(6) General condition of drives.

It is, therefore, impossible to lay down any hard-and-fast rule for the number of men required to maintain a certain amount of equipment or a certain number of motors.

In the following pages, I will discuss briefly the conditions encountered and the electrical organization that is required to maintain a modern blast furnace plant and byproduct coke plant, in the hope that this may be interesting to men in other plants.

The type of equipment used in a plant of this kind has to be rugged and designed to stand very hard service. In fact, there are few if any service conditions that are harder on electrical equipment than those encountered in the iron and steel industry, as about every condition that is detrimental to the equipment is found. The plant referred to in this article consists of coal-handling equipment for one battery of ovens, with the necessary charging, pushing, and coke-handling equipment for the byproduct and motor fuel departments, which have been in continuous operation for nearly three years. In addition there is ore and coal stocking equipment consisting of car dumper, ore bridge and transfer cars for one 600-ton blast furnace, with stock-house, cast house, pig machine, ladle house, sinter plant, boiler house, pump house, power house and shops. All of this equipment has been in continuous operation for over five years with the exception of a six-weeks' shutdown three years ago.

The following motors are required to operate this plant:

Number of a.c. motors	50
Number of d.c. motors	131
Total number of motors	181
Connected hp. of a.c. motors	2,168
Connected hp. of d.c. motors	3,037
Total connected hp.	5,205

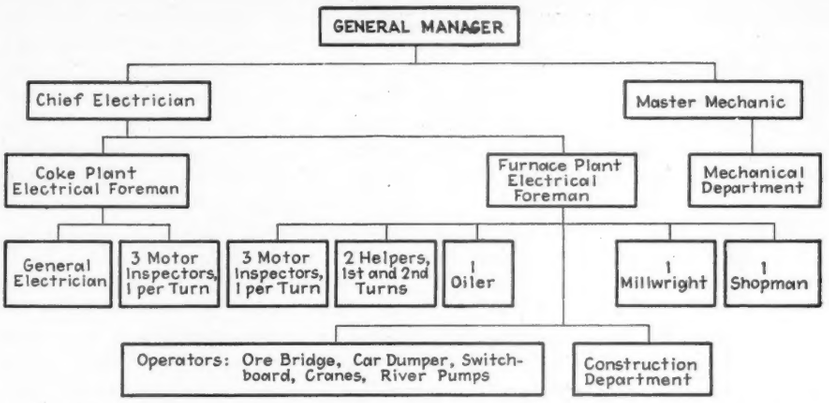
The generating equipment for

these motors consists of 7,000 kw. in steam turbines, 1,500 kw. in motor generators at the furnace, and 300 kw. at the coke plant.

At the coke plant the Electrical Department takes care of the electrical apparatus only, their responsibility ceasing at the motor pinion. The Mechanical Department takes care of the remainder of the maintenance work. Also, all of the operators are directly under the supervision of the Operating Department. A very small electrical maintenance department is, therefore, possible.

At the furnace plant the Electrical Department takes care of the maintenance of all electrical equipment including the motor pinions and couplings, and is responsible for the mechanical maintenance, exclusive of cables and buckets, on three cranes, the ore bridge, car dumper, and skip hoist. All crane operators, bridge, and pump operators also come under the supervision of this department.

The accompanying chart shows the entire electrical organization. As will be seen, five men are engaged in electrical maintenance work at the coke plant and nine men on electrical and mechanical maintenance at the blast furnace. These fourteen men take care of the 181 motors 24-hr. a day, 365 days a year.



The organization of the Electrical Department is shown on this chart.

Close co-operation is necessary between the mechanical and electrical departments in a plant of this size as these departments must work hand in hand. For large jobs on the ore bridge, car dumper, and the like, the Mechanical Department supplies what rigging is necessary and also gives help on the heaviest work, such as changing drums and wheels, and riveting.

Practically all of the equipment in these plants operates on what we will call a continuous cycle. For example, a coke pusher pushes an oven every 15 min. Between pushes it levels freshly charged ovens, and handles the oven doors. This cycle is continuous 365 days a year, barring breakdowns. Another instance is a furnace skip hoist. As long as the furnace is in blast the skip hoist must be putting up stock. There are short periods of time when the furnace is full that the hoist is down; otherwise, it may be considered to be operating on a continuous cycle. Failure of the skip to operate means slack wind on the furnace, with consequent loss of tonnage and bad effect on the furnace operators.

To inspect properly maintained equipment operating on a continuous cycle is somewhat difficult, more so than is the case when the plant is shut down over the week end, when a thorough inspection can be given and plenty of time is available for repairs. In our case inspections must be made daily between operations and the inspector must watch his chance, so as not to interfere with the operating schedule. Each motor inspector fills out a report, shown in the illustration, at the left giving the kind

Here is the report form that each motor inspector fills out daily.

FORM 86 150 6-20-227

THE TRUMBULL-CLIFFS FURNACE COMPANY
MOTOR INSPECTORS DAILY REPORT

Date 5/1/27
Turn 1st

CAR DUMPER	Inspected (Yes) (No)	Condition O. K.	No.	Mins. delay none
Time of Trouble:	Nature of Trouble			
Installed brushes on N. Propelling Motor				
ORE BRIDGE	Inspected (Yes) (No)	Condition O. K.	No.	Mins. delay none
Time of Trouble:	Nature of Trouble			
STOCK HOUSE	Inspected (Yes) (No)	Condition O. K.	No.	Mins. delay
Time of Trouble:	Nature of Trouble			
FURNACE AND HIGH LINE	Inspected (Yes) (No)	Condition O. K.	No.	Mins. delay 3 min
Time of Trouble: 12 am.	Nature of Trouble			
Repaired shunt on Skip Hoist Limit Sw. - 1st Slow down				
PIG MACHINE AND LADLE HOUSE	Inspected (Yes) (No)	Condition O. K.	No	Mins. delay none
Time of Trouble:	Nature of Trouble			
PUMP HOUSE	Inspected (Yes) (No)	Condition O. K.	No.	Mins. delay none
Time of Trouble	Nature of Trouble			
Installed 1-700W-120V lamp				
BOILER HOUSE	Inspected (Yes) (No)	Condition O. K.	No.	Mins. Delay none
Time of Trouble:	Nature of Trouble Fused N. side lights			
MACHINE SHOP	Inspected (Yes) (No)	Condition O. K.		
Time of Trouble:	Nature of Trouble		No.	Mins. delay none
SINTER PLANT O.K. cleaned motors + panels + checked air gap				
DOOR THICKNER OK				

GENERAL REMARKS:
Ground on D.C. @ 3:35 am - 9:45 am. found piece scrap on Ore Bridge Hot Rails

Motor Inspector J Fonley. Approved O.E.C.

and location of the equipment, nature of trouble found, if any, time lost, and repairs or adjustments made. With the help of these daily reports we are enabled to keep a very close check on the condition and performance of every piece of equipment.

When a repair becomes necessary, all preparations must be made beforehand so that the least possible time will be lost while the work is being done. In some instances production is quickened up a little ahead of time in order to gain time for the repair.

Repair jobs are often held up until a shutdown is required for other reasons, such as changing cables or other mechanical work; then with the whole force thrown onto one piece of equipment the repair job is quickly put through.

To carry out successfully any system of handling maintenance work the inspections must be thorough and the department head must know the exact condition of his equipment at all times. He must have a list of the repair work that is required to be done on a certain piece of equipment; he must watch to see that the condition of any equipment needing repair does not become too serious and cause a breakdown; and he must use his judgment as to when he can have the work done without causing a delay to production.

In the case of small motors of which there are a good many duplicates, a number of spares are kept on hand. If inspection shows that one of these motors in service has worn bearings, bad commutator, or is in a dirty condition and may give trouble, the spare is made ready for installation with a new or spare pinion, and a change is made at the first favorable opportunity. The replaced motor is then taken to the electric shop and given a thorough overhauling. When this work is completed, the motor is given a running test so that when it is installed in the place of another, it is known to be as good as new.

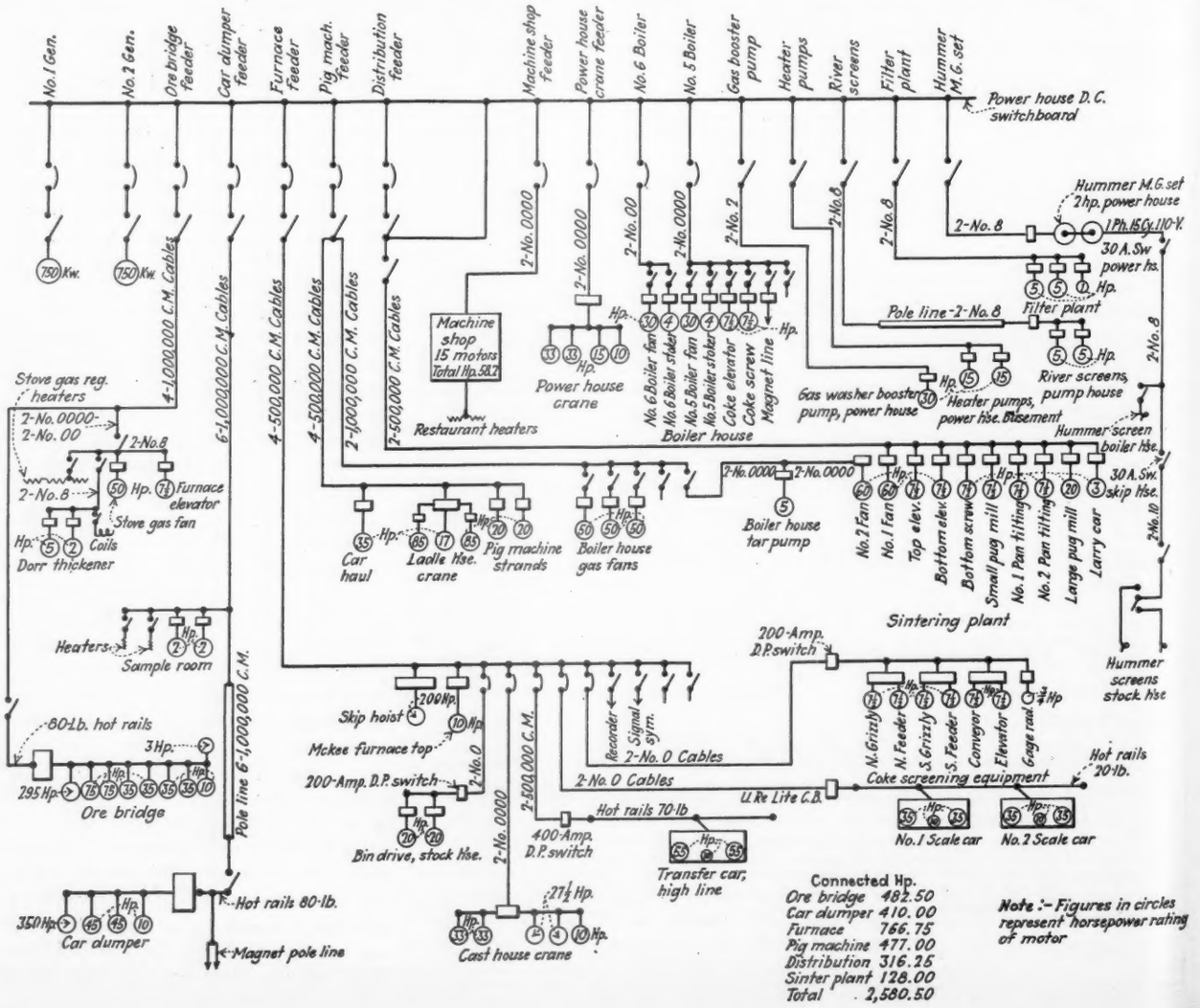
If it is found that a winding is in bad condition, a new one is put in, instead of making a patch job that may break down and cause a bad delay.

All rewinding is taken care of by one man in the repair shop; new coils are purchased from the manufacturer of the motor and installed by our winder. Bearings are babbitted by the Electrical Department force. All millwright and machine work is done in the machine shop, the machinist working under orders from the head of the Electrical Department while he is engaged on such work.

We keep a record card, one of which is shown on page 275, for every motor. This card contains complete data on the motor, including the nature of repairs needed, and their cost.

When cases of trouble occur every effort is made to improve the condi-

Layout of direct-current power circuits in blast furnace plant.



tions causing the trouble. In one case where considerable bearing trouble was encountered with the motors on a slag pit crane, the installation of roller bearings on all of the motors on this crane has entirely eliminated this trouble. The value of this policy of clearing up sources of trouble is shown by the fact that after five years of continuous operation less repair jobs were handled in the past 12 months than ever before.

Ground lights are installed at various points around the plant, on both the a.c. and d.c. circuits. As soon as a ground appears it is the motor inspector's job to locate it and get it cleared before serious trouble occurs. The installation of a recording voltmeter is being considered so that a check on this important condition may be available at all times.

A blueprint of the feeder circuits is given to each inspector so that he can become familiar with all equipment connected to each circuit. We find that this helps in locating grounds. One of the illustrations shows the d.c. circuits in the blast furnace plant. An insulation resistance test is made with a Megger at certain times, or when any equipment is down for repairs. A record is kept of these readings.

Most insulation failures on motors can be traced down to two chief causes: overheating, causing baking of motors, or deterioration due to dirt, oil, or fumes. The latter are ever present in a coke and furnace plant in the form of fine coal and coke dust, flue dust, and flake graphite. All of these are very bad for insulation inasmuch as they are good conductors themselves and if allowed to accumulate will quickly cause trouble. For this reason, a large proportion of our motors are totally enclosed.

A large amount of trouble can be prevented if the right kind of men are employed as inspectors and properly trained to handle their jobs. A good man soon finds that the more carefully he inspects and keeps up the equipment for which he is responsible, the less work he has to do.

It is my opinion that a bonus scheme could be worked out for nearly all maintenance departments, arranged so that the inspectors and maintenance men will receive a bonus based either upon the decrease in maintenance costs for the department as compared with previous years, or upon the decrease in the number of breakdowns occurring. A carefully-planned and fair scheme of this kind would insure the maximum of co-operation and effort.

A record card like this is kept for each motor in the plant.

FORM TC 44 100 4-31 A.B.&.CO. 10403

RECORD OF D. C. MOTOR — SHOP NO. M-41

THE TRUMBULL-CLIFFS FURNACE CO.

ELECTRICAL DEPT. — Furnace WORKS

MAKE	H.P.	SHUNT FIELD COILS No.	STYLE	SERIES No.	STYLE	AIR GAP	RAILS	STYLE	BRUSHES No.	SIZE	PULLY OR PINION DIAM.	PITCH	TEETH	FACE	KIND
Wbac	27.5	—	—	4	45277	1/16"	—	—	2	1"x2"x2½"		3DP	16	4"	H.T.
TYPE	R.P.M.					BEARINGS FRONT—REAR									
K	585	TURNS	WIRE	TURNS	WIRE	STYLE	Rollway		STYLE	BRAND					
FRAME	WINDING	—	—		Strap	KIND	Roller		456028	NCC 401					
7	Ser.	INTERPOLE FIELD COILS				LENGTH			BRUSHHOLDERS		PURCHASE DATA				
STYLE	RATING	none							No.	STYLE					
7V381	Crane	ARMATURE COILS				BEARING BORE			2	45407-A					
FIELD No.	VOLTS	No.	STYLE	FORM	ODM	SHAFT DIAM.	2 7/8"	2 7/8"	COMM BARS		DESCRIPTIVE NOTES				
7V55806	230	37	45357						No.	KIND					
DIM DWG.	AMPS.	TURNS	WIRE	CONNECTION		WIDTH	KEYWAY	DEPTH	79						
	110	2	#8 DCC			7/8	x 7/16								

ARM No	IN	OUT	APPLICATION	LOCATION	LOC. IN	IN	OUT	REMARKS
	9/10/26		Holding Line Hoist	East Ore Crane				

NOTES, TEST, DATA, Etc.

RECORD OF REPAIRS

DATE IN SHOP	DATE OUT SHOP	NATURE OF TROUBLE	NATURE OF REPAIR	COST OF REPAIRS MATERIAL	LABOR	TOTAL	NOTES
3/27/24	4/1/24	Low Bearings	new Bearings installed	7 15	5 00	12 15	
7/5/24	8/1/24	Roller Bearings installed					
9/4/25	9/8/25	Bottom field grounded	new field installed	29 00	14 00	43 00	
5/2/27		Arm Grounded	Rewind arm	38 50	24 00	62 50	

NOTES ON REPAIRS

Steel Mill Power Drives

(Continued from page 255)

been developed which yield more light per unit of current consumption.

Roll Heaters—That there are now 164 roll heaters operating in the sheet and tin mills of 19 plants is the report received from Freyn Engineering Co. Results in these plants show that the use of electric roll heaters has increased first-turn production about one-third and decreased scrap loss by 10 per cent.

The increase in production is due to the fact that rolling can be started on orders of any gage or width within the capacity of the mill, practically from the first sheet bar fed into the rolls. This eliminates the necessity of warming up iron. As a result the production on the first turn approaches midweek values.

Electric Furnaces—In the field of electric arc melting furnace equipment, the general tendency is to build furnaces of larger size and provide for higher rates of power input. This has been made possible by the use of three-voltage switching.

When the cold charge is first placed in the furnace, it is capable of absorbing heat at a higher rate than after it has become molten; that is, with the cool metal the temperature of the furnace walls is not increased beyond the permissible value by the increase in the rate of energy input; hence a higher voltage can be used than would be used later in the heat.

When the temperature of the walls has become as high as permissible, it it possible to switch to the next lower voltage tap and supply energy to the furnace at a lower rate. Finally, when this rate of energy input is also undesirably high, it is possible to switch to a still lower furnace voltage and reduced energy imput.

The electric furnace has become an important factor in the steel industry in the production of tool and alloy steels. Among the largest of these recently installed are two 15-ton and a 25-ton Heroult furnace. A Westinghouse arc furnace regulator is used with these furnaces.

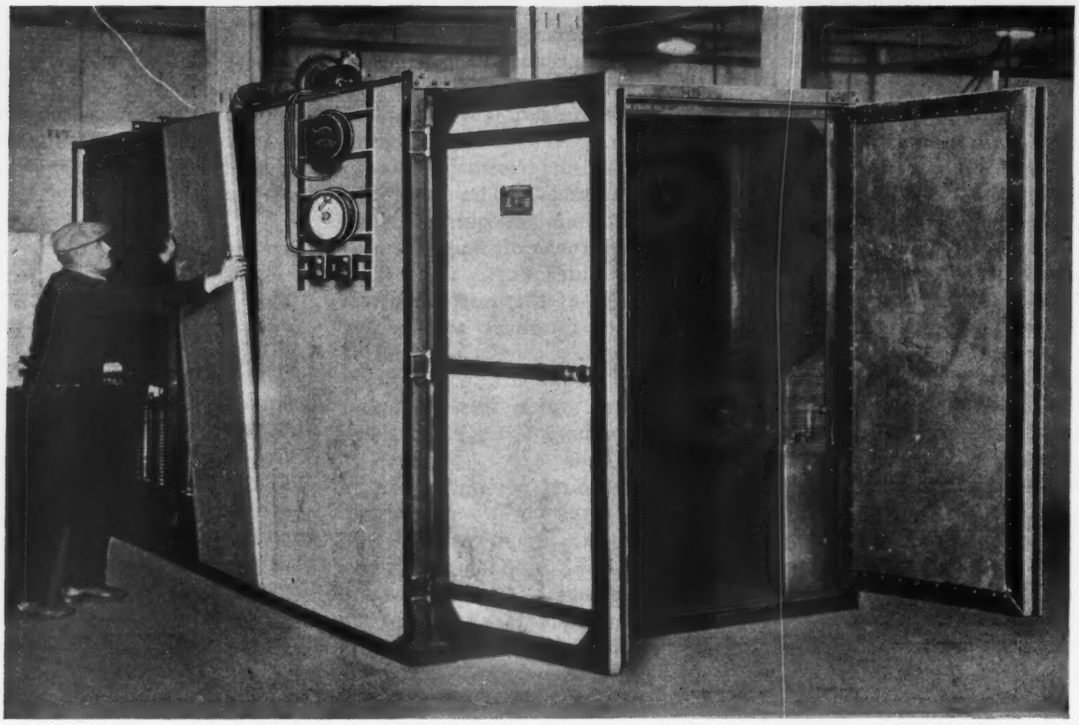


Fig. 1—The ventilating equipment for this box-type oven is controlled from a push button on the side-wall rack, which carries the thermostat and temperature indicator. A second push-button station controls the heating elements.

Low-Temperature Electric Ovens

for industrial applications

By EDWIN FLEISCHMANN

Industrial Heating Engineer, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

ELECTRICALLY - HEATED ovens designed for temperatures below 700 deg. F. have been used for baking bread, or japans, carrying on drying processes of many kinds and performing numerous other similar operations for years with great success. The economy of electric heat as compared with other fuels decreases very decidedly as the temperature goes down, but there are often other factors which take precedence over fuel cost in such work, so that electricity is frequently the only heating means considered. Reduction in fire hazard, fewer rejections, and less shrinkage are among the factors to be taken into account.

In the average electric oven, the simplicity of construction is a point to be borne in mind constantly. The temperatures are so low that with the exception of the heating elements, steel may be used for all parts of the oven. The only important and somewhat technical phase of oven work is the ventilation, of which more will be said later.

Fundamentally, an electric oven consists of a supporting structure with thermally-insulated walls, a means of getting charges into and out of the enclosure, a heater of some sort within the oven, and, when necessary, suitable ventilating equipment.

In choosing an electric oven, the floor space available will determine whether a box type or conveyor unit can be used, while the amount of production will indicate whether a conveyor oven would be justified. The operation which is to be carried on in the oven will also have a very great bearing upon the character of the equipment. It is obvious that one would scarcely use a conveyor type oven for baking cores or armatures, although, at the present time the former is being done successfully. Not only must the material to be baked or dried have careful consideration, but the duration of the complete cycle also. While cycles of short duration lend themselves more readily to continuous working, very long cycles will be best suited to batch production in box-type ovens.

The kind of heating to be carried on in the oven will determine as well the amount and kind of ventilation required, the method of handling the material, and the installed electrical capacity. The flexibility of the electric oven makes it possible to place small units at strategic points, where they will work best into the production arrangements of the shop. By this means, economies may be effected by reducing the handling costs.

When small, box-type ovens are employed, it is always advisable to make use of standard sizes, of which there are a large number available,

and it is not serious nor disadvantageous to have an oven slightly too large for the work being done, unless the installed capacity is entirely out of proportion. The latter, however, can usually be adjusted by the manufacturer to suit the existing conditions, so that, an oven is obtained at a price, which would be much more reasonable than for one specially constructed. Although electric ovens are comparatively simple to construct, many manufacturers are inexperienced in the arrangement of heating elements, thermal insulation, and in the proper provision for ventilation. If, however, these three factors are checked carefully there is no reason why any manufacturer of ovens cannot make a satisfactory electric oven. Too much stress cannot be laid on the importance of care in design with regard to these three matters.

Ordinarily the framework of ovens is made of structural steel, consisting of angles and channels, which support the wall panels. Careful bracing is necessary to insure sturdiness of the framework, so that there will be no warping under the influence of the heating and cooling of the walls. Although the outside surface of the walls normally runs at a very conservative temperature, silght changes due to heating and cooling often serve to weaken the supporting structure, so that the oven becomes unsteady. This is particularly important where the work runs into or through the oven upon a rail, or conveyor, supported from the roof or on the floor.

The floor contruction is of very great importance in ovens which employ racks mounted on trucks, or wherever heavy loads will rest upon it. It is usually supported upon channel irons, closely spaced, and so arranged that the amount of through-metal is a minimum. A heavy boiler plate covering serves as the floor itself. Where tracks are used they are supported directly on the channels which rest upon the ground or shop floor. Insulation is applied between the tracks and the channel irons to reduce the losses from the bottom of the oven.

The most commonly used substance for the insulation of low-temperature ovens is mineral wool, a fibrous material which results when a blast of steam is sent through molten slag or rock. It is made up in several forms, and can be obtained either in bulk, or in felted form, in slabs of convenient dimensions.

Other insulations are sometimes employed but as mineral wool has a very low coefficient of thermal conductivity, it is in almost universal use. At temperatures up to 200 deg. F., 1 or 2 in. of thickness are generally sufficient; between 200 deg. F. and 400 deg. F,, 3 in. will be ample; and from 400 deg. F. to 700 deg. F. at least 4 in. should be used on ovens of any considerable size. The thickness will depend not only upon the temperature, but also upon the size of the oven, as the losses are directly proportional to the area of the outside surfaces.

In most cases, the walls of ovens are made up of a number of panels, each panel consisting of a structural iron frame with sheet metal coverings, between which is the mineral wool insulation. There are many different types of panels now in use, the chief feature of all being the reduction of losses, either partially, or wholly by the elimination of through-metal. It is evident that reducing the cross-section of the metal which passes through the panels from the heated enclosure on the inside to the room temperature on the outside, reduces the amount of heat which will be lost through the walls. It is wise, therefore, to make the wall panels in such a way as to keep the through-metal losses at a minimum.

On the other hand, the panels must be braced against unequal expansion and contraction to which they will be subjected by the high temperature inside the oven and the low temperature without.

The wall panels and roof panels are usually assembled upon the structural framework, when the oven is set up in the shop, in the manner shown in Fig. 1. The panel construction makes the assembly simple and expeditious.

When doors are used, it is well to be sure that they are tight fitting and provided with a positive latch which clamps the doors shut and holds them so during heating. Furthermore, they must be braced to withstand distortion due both to unequal heating and to the stresses incident to opening and closing. It is also important that the body of the oven be rigid enough to withstand these shocks, and to hold the weight of the door when open. If there are to be doors at both ends of the oven, firm bracing of the body of the oven is especially necessary.

The width of the oven determines whether single or double doors will be used. It is impracticable, however, to use single doors on large ovens because of their weight, and the fact, that the swing will be so large that too much additional floor space will be taken up by the equipment.

The insulation on the doors should be of the same thickness as the walls. Although there will always be larger

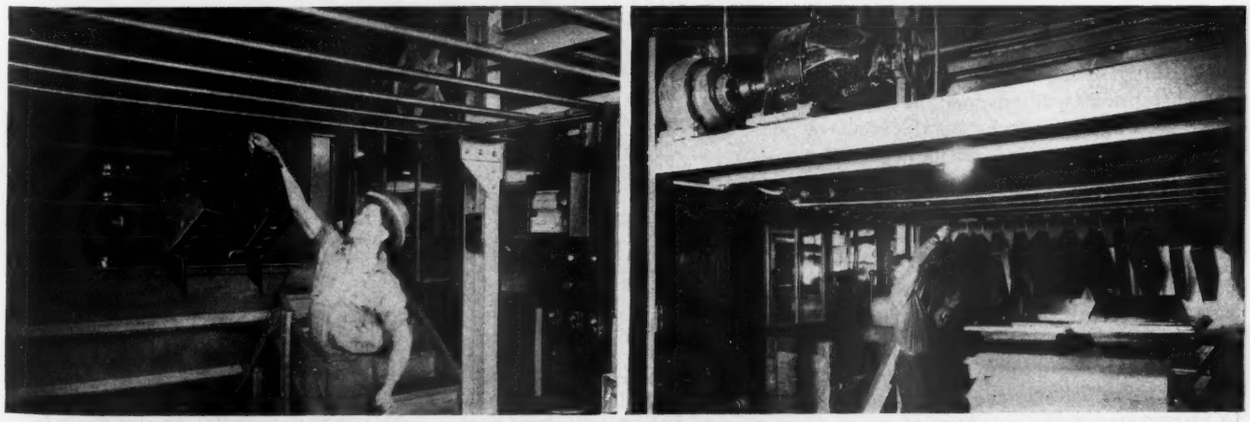


Fig. 2—The modified A type continuous-conveyor, japanning oven. The view at the left shows the charging end, conveyor, dipping tank, and control panel with temperature recording instrument. The view at the right shows the exit end where the finished work is being removed from the conveyor. The conveyor drive equipment is shown mounted overhead.

losses around the door, the face of it is subject to the same conditions as the walls of the oven, and it is well to conserve as much heat as possible. As a further precaution, switches should be provided which cut off the current whenever the door is opened. This not only saves electrical energy, at a time when it would otherwise be wasted, but also protects the workmen from injury during loading and unloading.

In very small ovens, no means of holding the charge are provided, except where a number of shelf supports, usually movable are mounted on each side of the oven. Upon these are placed or hung, shelves, rods, or racks of any kind suitable to the work.

In larger ovens it is frequently desirable to load the racks outside the oven. In this case, the load is moved into the chamber and out again by means of a lift-truck; sometimes the whole charge is mounted on a car. The latter is often employed for heavy work such as railway motor armatures.

It is important, that all parts of racks or trucks to be used in ovens be made of metal. Steel is commonly used and is most satisfactory at oven temperatures. All joints should be welded or riveted.

The various types of conveyor ovens present problems in themselves. Here the work is hung on moving racks and carried into the oven automatically or partly so. The simplest batch-type conveyor oven is the so-called semi-continuous conveyor unit. Where production is on a small scale, this type of oven is often preferred. The work is hung on the conveyor at one end, while one charge is heating. The cold charge is pushed into the oven, and the baked charge comes out the opposite end to be unloaded. The operation can be made continuous or not, as fluctuations in the production rate dictate.

Finally, the full-continuous conveyor type is still in use for large production operations, where the work is automatically dipped, drained and baked by being hung on the conveyor cold at one end as shown in Fig. 2, and removed, completely baked, at the other end.

Ovens of this type are made in various shapes, varying from the old "tunnel" style, of which many are still in use, to the latest A type or modified A type, of which the oven shown in Fig. 2 is an example. The variations of shape are due chiefly to improvements in economy of operation, by more efficient ventilating arrangements. Another type of construction that has been used successfully, is that in which the work travels in a zig-zag, up-and-down motion through the heating chamber, and finally is brought back to the loading end for discharge.

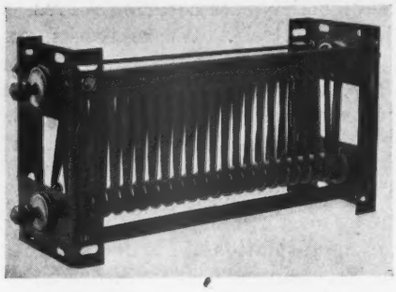


Fig. 3—This is a small convection-type heater for low-temperature electric ovens.

Two projecting rods form the terminals of the heater. Nichrome ribbon is wound on porcelain bushings and uniformly distributed over the entire length.

In general, the arrangement to be selected will be that which most nearly meets all the requirements and limitations imposed. Where the floor space is limited the box-type, semi-continuous conveyor oven may have to be used. The "tunnel" type will be indicated if head-room is restricted, for under these conditions it will be almost impossible to use an A type or modified A type oven.

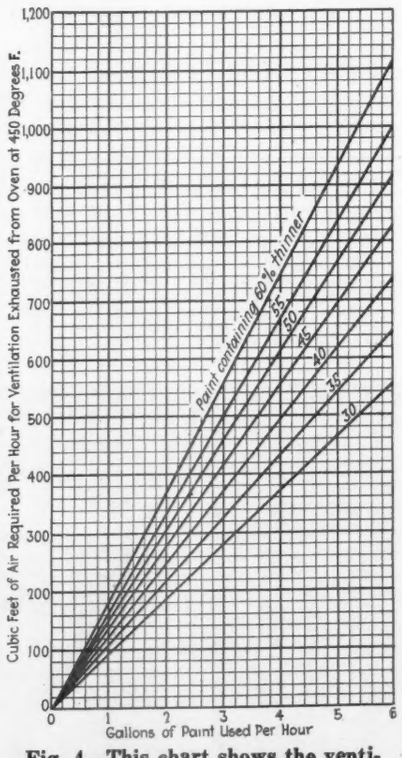


Fig. 4—This chart shows the ventilation required to remove fumes from low temperature ovens.

For oven service a conventional type of low-temperature heater is required, for example, like that shown in Fig. 3, wherein the Nichrome ribbon is uniformly and openly distributed throughout its length, to permit free passage of air through and around the turns. Insulation is ordinarily obtained by means of porcelain bushings mounted on a rod.

A substantial cross-section of ribbon should be used to insure long life; and, although the rating in watts per square inch of peripheral surface of the ribbon is not so vital here as in the case of furnaces, conservatism still means long life. The heater shown in Fig. 3 is rated slightly above 5 watts per square inch, which is considered a safe rating, even at furnace temperatures.

The ribbon should be wound loosely in order to allow for the expansion of the frame under heat, but not so loose as to permit short-circuiting between turns.

In mounting the heaters on the walls or floor of an oven, it is important to make sure that the ribbon is supported at a distance sufficient to prevent grounding. This is ordinarily taken care of by the width of the end frame. The same precaution is needful in regard to protective screening and baffles mounted in front of the heaters. In long heaters, that is, over 2 ft., some means should be employed to keep the spacing of the rods correct. A porcelain spacer is often used midway in the span.

A word of warning is necessary here against the use of asbestos in any form as a means of supporting the heating wire or ribbon. At oven temperatures asbestos gradually dehydrates, becomes powdery, and early in the process loses its electrical insulating property, so that grounds are frequently experienced. The seriousness of this danger appears especially in ovens where volatile vapors are given off from the work, as in japanning. The connection of the nickel-chromium ribbon to the steel terminals of the heater is important because of the unequal expansions of the two metals, when heated.

Interconnection of heating elements in the oven is made by the use of strap-iron connectors and clamps. Cold-rolled steel busbars are also used, and various sizes of clamps are made to suit. It is important that the connections be made by clamping, rather than bolting, or riveting, as provision must be made for the

motion of the busbars under expansion and contraction, without loosening or destroying the electrical connection.

Steel is used for connectors, clamps, and busbars in preference to copper, because it resists oxidation up to approximately 700 deg. F., whereas, copper oxidizes rapidly at fairly low temperatures. As a guide in keeping the temperature of the busbars down to a reasonable and safe value, the accompanying table of current carrying capacities of various usual sizes at different temperatures may be of interest.

As practically all of the heat in electric ovens is carried by convection, that is, through the medium of circulating gas, vapor, or air, heating elements are normally placed as near the floor as possible.

In box-type ovens, they will be placed along the walls in order to be out of the way of trucks and work, and when so arranged the incoming ventilating air is forced through them from below, or from the side, in order to be heated before encountering the work. In some cases, heaters are also mounted in the center of the chamber, in order to equalize the heat distribution.

In conveyor-type ovens, heaters are mounted either on the walls or floor of the oven, but in the latter case they must be carefully covered, especially through the entering sections of the oven, in order to prevent drippings from fouling them. In some of the older continuous-type ovens the distribution of heaters had to be varied in order to obtain the proper temperature zoning.

In the A type, or modified A type, ovens the heaters are mounted on the floor or walls of the elevated section. The work is being pre-heated as it rises to this point, is baked while passing over the heaters, and cooled as it descends to the exit end. In general, the heaters should be arranged so as to give the temperature distribution or cycles of heating required. It is scarcely necessary to concentrate the heat near the doors, as is the case with furnaces, as the ventilation of a continuous oven can be so designed as to compensate satisfactorily for the losses at this point.

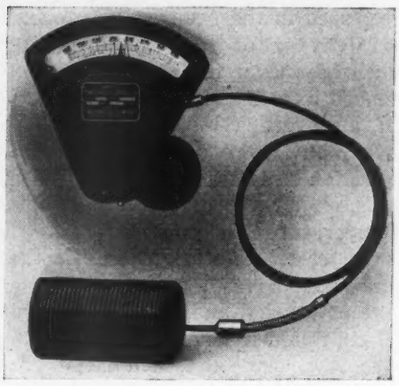


Fig. 5—Here is an electric-contact-type control thermostat with extended bulb.

The coiled bulb is placed in the oven. The contacts are moved by the variation of pressure in a Bourdon tube in the instrument.

One of the most important features of electric oven design is the method used for circulating air through the chamber, which includes the quantity of air exhausted as well. In all japanning operations where the solvents of the paint are volatile materials, such as ether, benzine, or naphtha, the ventilation plays a most important part. For work such as drying or armature baking, natural ventilation is often sufficient. In any case, some circulation if properly directed will improve the temperature distribution in the oven. Without ventilation, the heated air will naturally rise to the top of the oven and be pocketed there while the bottom will be cooler by 100 deg. or more.

In small, box-type ovens for armature baking or light drying jobs, natural ventilation is ordinarily provided, by means of vents along the walls under or behind the heaters, which serve as intakes, and a larger vent in the roof with a damper, so that the outflow of air may be controlled. In order to increase the flow, the exhaust is often connected to a stack, so that a slight draft may be obtained.

Mechanical ventilation is almost always used in larger ovens, and invariably so in conveyor ovens, because the motion of the work makes positive control imperative. The intake is a pipe along the floor under the heaters, and the exhaust is either through a flat pipe along the floor, or from the roof, or both.

The vapors from japans are heavy, so they can be exhausted best along the floor. It is advantageous sometimes to exhaust from both points in order to equalize the temperature distribution, but this will depend largely upon the nature of the work and the character of the charge. Air is taken into the oven through the heaters, and in order to insure its passing over the coils, baffles should be provided in front of them. The importance of careful baffling cannot be over-emphasized, as it affects the entire temperature distribution in the oven, and if skillfully done can greatly increase the useful volume of the oven.

In the latest modified A type ovens, a sort of recuperative ventilating scheme is employed in which the efficiency is materially increased. The hot gases are drawn out of the oven at the entering end, while the cold air enters at the exit end, so that some of the heat of the gases is imparted to the cold work, and in turn the baked parts serve in a measure to heat the incoming air. A very strong suction is required, however, to prevent the gases from coming out into the shop.

The amount of ventilation needed varies in different applications and with different types of ovens. Armature baking requires about 15 changes of air per hour, core baking requires from 20 to 40 changes per hour and ordinary drying processes from 30 to 60 changes.

In armature baking it is not wise

Maximum Safe Capacities in Amperes for Cold-Rolled Steel Busbars

Operating Temperature of Oven Chamber, Deg. F.	Size of Busbar in Inches				
	1 x ¼	1¼ x ¼	1½ x ¼	1¾ x ¼	2 x ¼
200	120	160	200	240	285
250	115	155	195	235	280
300	110	150	190	230	270
350	105	145	185	220	260
400	100	135	175	210	250
450	90	125	165	200	240
500	75	110	150	185	225
550	60	90	125	160	200
600	45	70	100	130	160
650	30	45	65	90	115
700	15	25	30	45	60

to recirculate the air, but for core baking and drying, from one-half to three-quarters of the air may be recirculated. In the case of japanning, or drying paints and lacquers, the number of changes of air depends entirely upon the quantity necessary to keep the concentration of volatile vapor in the oven below the value at which explosion will occur under the prevailing conditions of temperature. There should be no recirculation. The curve shown in Fig. 4 may serve as a safe guide in this respect, for it represents the results of exhaustive research upon the subject.

Whenever forced ventilation is employed the blower should be so mounted that the motor and fan bearings will not be overheated by conduction. It is the usual practice to place the bearings some distance from the fan housing so as to prevent interference with lubrication.

The fan itself, particularly when it is used to exhaust japanning vapors, should be of the straight, paddle-wheel variety for it has been found dangerous to use fans with curved, or Venturi blades because the heavy vapors condense on them and fill up the curves, gradually reducing the effective discharge area, so that the correct volume of air is no longer handled. Oven explosions have been traced to this cause.

Ample ventilation in an oven is necessary, even though it may decrease the efficiency somewhat. Excess ventilation is absolutely essential for such applications as temper-drawing ovens where the temperature distribution is vital.

The control of temperature in electric ovens is accomplished in a manner similar to that employed with in furnaces. The only difference is that a thermostat instead of a pyrometer is used. The thermostat has three electric contacts within it: a low, high, and common. The common contact is set for the temperature at which the instrument is to control, and the other two, a fixed distance apart move in response to the variations of temperature in the oven. When the temperature rises to the desired point the high contact touches the common, causing the oven current to be shut off. The temperature then drops until the low and common contact touch and cause the oven heaters to be energized; and so on, while the oven is in operation.

The bulb of the thermostat, which is placed in the oven, may be either straight or of the extended type, such as shown in Fig. 5. The extended bulb is supposed to give more of an average temperature in the oven, but there seems to be some question as to whether it really does this, or actually gives the maximum temperature it encounters. It is superior to the straight bulb in that the latter gives the temperature at one point only, and controls the oven at that value. The variations which are to be expected in a large oven make this an inaccurate method of control.

The closeness of control to be expected from a given instrument depends entirely upon the physical distance necessary between the contact points and of course, the length of the scale. Variations in temperature scarcely less than 5 deg. F. can be obtained, although on very short range instruments whose contact points are set very close, this may be slightly bettered.

The current to the heaters is turned on and off by the thermostat acting through a relay and main line contactors. These, with fuses or an overload relay, are usually mounted on a slate panel which may be placed in any convenient location. The panels for large ovens are often placed in a room by themselves, as shown in Fig. 6.

In connection with the control a door switch is of importance and, for convenience, a push-button station is usually employed to start and stop the oven heating operation.

There is nothing particularly complicated about electric ovens, but it is important to remember that they must be especially designed for the use of electric heat, as fuel-fired oven construction is often very unsuitable in this connection. Most of the features of design depends, however, upon empirical data, because so little is known of convection.

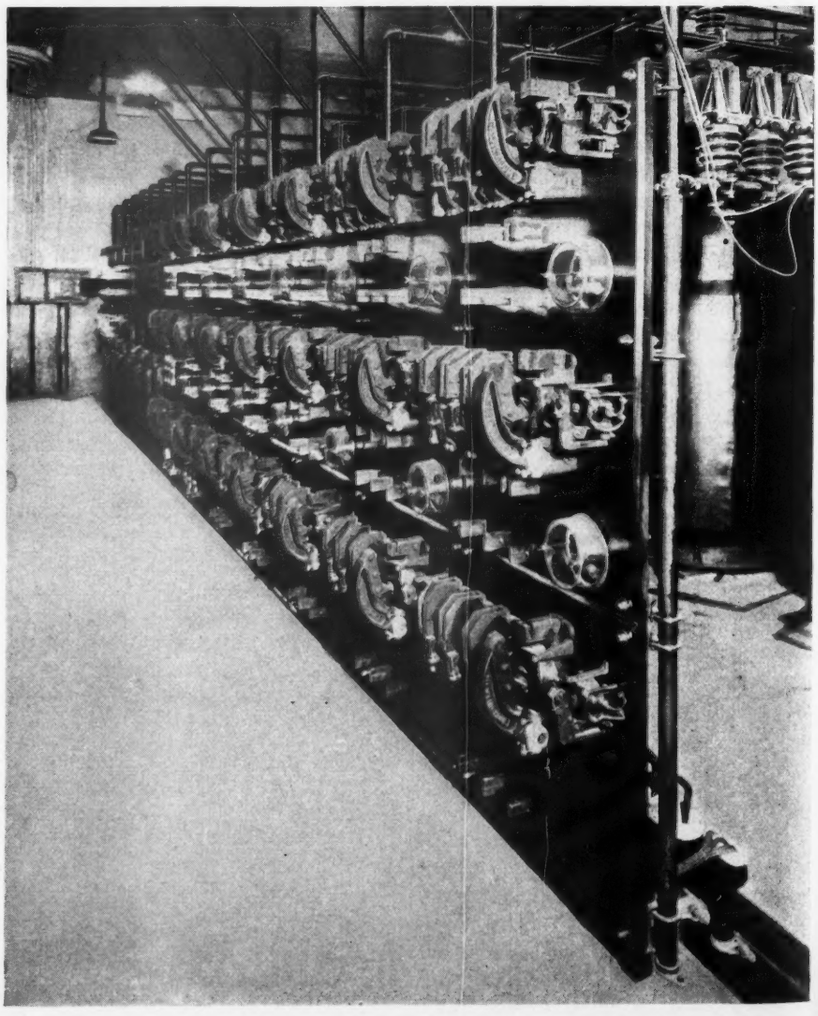


Fig. 6—Contactor panelboard controlling the various sections of a large oven installation.

The current to the heaters is controlled by the thermostat, acting through relays and main line contactors.

This is the type of welding transformer referred to in the accompanying article. Courtesy the Electric Arc Cutting and Welding Co., Newark, N. J.

How we make use of

Electric Arc Welding

to keep equipment in service

By J. S. MURRAY
Chief Electrician, Follansbee Brothers Co., Toronto, Ohio

WELDING has become a practical necessity in steel mill operation, where almost every piece of equipment is subjected to severe service with the resultant heavy wear and breakage that accompany such service.

When moving parts of a piece of equipment have even a small amount of play or backlash, the severity of a shock or reversing load causes wear which increases in rapidity and seriousness with the resultant increase in play. Although gears, pinions, and other sliding or rolling parts in modern steel mill equipment do not have the play which was a characteristic feature of the old-time equipment, nevertheless there is usually some. The abrasive conditions under which much of the equipment must operate also effects the wear.

Breakage is high because equipment is powered high to permit it to handle the heavy loads of operation and so, whenever anything interferes to cause sudden stoppage, something breaks. It requires a tremendous shock to break a 15-in. or 16-in. shaft, although this sometimes happens.

Before the perfection of welding and its application to steel mill operation, the loss from breakage and wear was a very serious problem because there was practically no salvage, except as scrap, from the broken and worn parts. Welding, as carried on at the Toronto plant of Follansbee Brothers Co., consists of repairing broken parts, building up worn surfaces, fabricating by cutting, fitting and welding, and cutting out and removing worn and other parts which it is desired to change or discard. Cutting is, in reality, the opposite of welding, but it is usually, and in this discussion will be, considered as a part of the welding work involved in the maintenance of equipment.

Before going further, it may be well to describe briefly the type of activities at our Toronto plant. This plant consists of open hearth furnaces, hydraulic presses for forging the ingots into bars, a bar mill, sheet mills, annealing furnaces, power house, coal mine, and the other auxiliary and necessary adjuncts to plant operation. A feature of this

"Large worn gears are removed and the teeth built up with the electric welding unit. The gear is then taken to the machine shop and the teeth recut. The entire rebuilding job, including the welding and cutting of the teeth, costs about $65, whereas a new gear would cost approximately $225. Gears with renewed teeth last practically as long as new gears, and the building-up process can be continued indefinitely."

plant, which is unusual, is that the ingots are reduced by forging under the hydraulic press instead of by a blooming mill, and rolled in a bar mill. The product of the mill is full-finished steel sheets which are used in automobile bodies, steel furniture, and many other varieties of finished product.

The Electrical Department has supervision over about 1,000 motors, rating from 2,000 hp. down to fractional-horsepower units. In addition, there are 27 cranes, the charging machines, forging manipulators, and coal mine machinery, as well as the distribution system to look after. This last division requires comparatively little welding, however, except in the construction of special shapes for mounting some of the equipment, and in the bonding of rails for the cranes and mine locomotives.

At this plant the repairs are divided between the Mechanical and Electrical Departments. The Electrical Department makes all repairs of either electrical or mechanical nature, connected with electrical equipment, or equipment which, in the nature of its operation, is primarily electrical, such as cranes, the charging machines, forging manipulators and other similar equipment. All repairs of any nature are made on this equipment, in addition to all purely electrical repairs. This includes repairs to bearings, gears, pinions, shafts, and so on.

The Mechanical Department looks after the remainder of the repairs to the mill, open hearth and other production equipment in the plant. Incidentally, a large amount of the repairs which the Electrical Department makes are in reality of a mechanical, rather than electrical nature.

The electric welder does work for both the Electrical and Mechanical Departments, and is kept busy most all of the time. Some work is, of course, of emergency nature and must be handled immediately. There is a large amount of work, however, which is placed in the welding room to be repaired or built up as opportunity affords. This material, after repairing, is placed in stock and issued out at the first call. For our electric welding we use a Type CW, 12-kw., 350-amp., 220-volt, single-phase, portable welding transformer manufactured by the Electric Arc Cutting and Welding Co., Newark, N. J.

In addition, both departments have acetylene welding and cutting outfits. Torch work for the Electrical Department consists usually of cutting, although the torch is also used on much of the light welding work and for brazing and non-ferrous metal work.

Use of the acetylene torch is one of the quickest methods for removing structural work of any nature and for cutting any other metal work, particularly where it is not desired to reuse it. Frequently, parts are badly worn or are not to be used again, and so it is more economical to remove and replace them than to try to weld or build them up. A man with a torch can cut away metal much more quickly than it can be torn down by disassembling.

"Guides on the bar mill rolls are also built up in place in two or three hours, whereas it would take practically a day to remove them. This is a big saving in labor, as well as in the cost of new parts for replacement. The decrease in delays to production is, however, one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel."

Cutting or fitting on the job, and to some extent in the shop, is practically all done by means of the acetylene torch. The Electrical Department naturally does not have as much of this cutting and fitting as does the Mechanical Department with its work around the open hearth furnaces, annealing and sheet furnaces and duct and pipe work. However, we keep the Oxweld gas torch busy cutting and on some welding, in addition to the work handled by the electric welding unit.

It is difficult to list or describe the multitude of welding jobs which go through the shop as a regular part of the daily routine. They vary from jobs weighing a ton or more to light sheet metal. However, I will try to enumerate a few of the things that are done in this plant. In doing this I will first take up the use of the electric welder. All steel filling is done by the electric welding unit.

In motor maintenance the wear on keyways, particularly on cranes, is a very big item. These keyways are filled in and recut and the entire shaft salvaged at a very low cost. Such a repair requires very little more work than would be necessary to press out the old shaft and insert a new one. Bores and keyways in track wheels, brake wheels and so on, are welded and machined in a similar manner.

At the present time we do not build up motor shafts that are worn at the bearings. When such shafts become worn to a certain point, they are replaced with new shafts.

Heat-treated, tool-steel pinions are used on all crane motors and in some other places where the service is exceptionally severe and the gears are exposed to large amounts of abrasive material.

In the case of large steel gears, such as on the internal ring gear on the forging manipulators and on the charging machines, the swinging of the trolleys results in heavy wear on the teeth over a portion of the circumference. These worn gears are removed and the teeth built up with the electric welding unit. The gear is then taken to the machine shop and the teeth recut. The entire rebuilding job, including the welding and cutting of the teeth, costs about $65, whereas a new gear would cost approximately $225. This cost does not include the labor of removing the gear or replacing it, because that would be the same whether a new or salvaged gear were used. Gears with renewed teeth last practically as long as new gears and the building-up process can be continued indefinitely.

When a tooth of a gear is broken it is built up and recut in the same manner. It would be difficult to make an estimate of the amount saved by rebuilding teeth in gears alone, but I may say that this is one of the largest single types of work that we have to do.

Frequently it is possible to use the electric welding unit to build up a worn surface on a part which otherwise would be scrapped. For example, the head on the ram of the charging machine can be built up by the electric welder in about 10 hr. The cost of welding a new ram is between $300 and $400. In other cases welding can be done without removing the part from service.

Guides on the bar mill rolls are also built up in place in two or three hours, whereas it would take practically a day to remove them. This is a big saving in labor as well as

in the cost of a new part for replacement. The decrease in delays to production, however, is one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel. Also, when interruptions last for a considerable length of time it is sometimes necessary to practically close down a section of the plant, which is very expensive.

Another building-up job which is of especial importance is the filling out of the square ends of the roll spindles, wobblers, and coupling boxes. Such repairs represent one of the biggest items of saving of any made in the plant. In this instance the entire cost of repair is a small item compared with the cost of a new roll spindle.

In addition to the rebuilding of worn surfaces, the electric welding unit is used to unite broken parts of steel and most iron castings. To make a weld it is necessary to V out the material at the break so that the welder can build up from the bottom. In our plant this V-notch is cut with the acetylene torch on practically all jobs of considerable depth or diameter. The two parts are then mounted on horses and aligned in the shop and the metal is built in, beginning at the center. After depositing some metal the part is turned and a corresponding amount deposited on the opposite side to assist in maintaining alignment and to equalize any strains.

Such a weld is, we believe, as strong or stronger than the original.

When filling a large V the welder must be careful to deposit clear, solid metal without blowholes and make sure that each layer makes a firm bond with that previously deposited.

One interesting welding job was on a broken peel on an ingot charging crane. This was built up in a comparatively short time and did not require any machining to finish it. This peel was made of cast steel and was about 8 in. in diameter, with a cored center. A large bolt was placed in this cored opening to hold the casting straight. The welding metal was then deposited in the V-notch. The repair was made without dismantling in about 4 hr. A new casting would have cost approximately $200, so we were able to make a considerable saving.

During cold weather the cast-iron hydraulic cylinders on the transfer tables sometimes freeze. When this happens the cracks are chipped out and the holes filled in with the electric welder.

Gear guards for cranes are welded either electrically or by the Oxweld torch, whichever happens to be the most convenient. The latter is used, however, for cutting and fitting metal for the guards.

All brazing or welding of nonferrous metals is done with the Oxweld torch. It is also used for filling in blowholes or building up broken teeth in bronze gears. In one instance, a weld was made in the impeller of one of our centrifugal pumps, and on several occasions stuffing boxes have been built up and then rebored.

In addition to its use for cutting metal in reclamation work, the acetylene torch is also employed in cutting up large pieces of steel into scrap. For example, after annealing boxes have become warped out of shape and can no longer be used, they are cut up with a Prest-O-Lite torch into pieces small enough to go into the open hearth.

In addition to the arc welding outfit which has been described, we also use a resistance-type welder for welding track bonds in the coal mine which is a part of our property. Also, the rails which are used as conductors in the mill are bonded.

New jobs of different types are coming up every day and so we are constantly being called upon to do things which we had never thought of doing before. The application of welding to maintenance work grows in the plant as the men become familiar with the work and with the possibilities of their equipment. Welding is of especial importance in the steel mill because it affords a means of reclaiming economically many parts which would otherwise have to be scrapped.

Thermit welds are also becoming a very important addition to this class of work. We have had some 16-in. × 18-in. shafts welded in this manner by outside crews.

Elimination of Hazards in the Operation of Overhead Cranes

By C. E. SANKEY

Safety Engineer, National Tube Co., Ellwood City, Pa.

WHEN the word "hazard" presents itself to me, it is immediately followed by the word "overcome." It is the work of the safety man in any plant to overcome any condition that may cause accident or injury to an employee. My experience so far has led me to believe that the only way to overcome any so-called hazard is to educate the men not only to be cautious, but to be alert and awake to the dangers of the work they are doing and the machinery they are handling.

This paper* will devote special attention to the hazards incidental to the operation of cranes. All cranes are built according to certain code requirements, are technically right, and have been so proven by the tests called for in the specifications. The design is made to meet the needs of the department in which they are installed. The placing of lights, so as not to cast shadows on work being done, and clearance, because there should be ample floor space in the bay to enable the operator to see the load he is to lift as well as the men who are working with it, are two questions that should be given special attention because both are important from the safety viewpoint. As a man's environment influences his work to a great extent, it is essential that the crane cab be light and properly ventilated. Accidents have been caused by cranemen being drowsy, due to poor ventilation.

After a crane has been installed and tested, it is the duty of the Electrical Department to see that the brakes, limit switches, overload, and other safety devices are kept properly adjusted, and that the cranemen understand the mechanism sufficiently to take proper care of it, and to recognize immediately any condition that may lead to disaster. This training can be done in only one way, and that is by precept and example.

A man who is being considered for the position of craneman, and preference should be given to men who

*Note: From a paper read before the Erie Regional Conference, National Safety Council, May 17, 1927, at Erie, Pa.

have been employed in the department for some time and know working conditions and the class of material to be handled, should have a physical examination with special attention to sight and hearing.

Cranemen should be relieved of any responsibility arising from disputes. These should be settled by the foreman because a craneman who harbors resentment and anger toward those with whom he is working may be tempted to retaliate, if he thinks he has been unjustly treated, and the result may prove disastrous. In addition to being given a copy of "Rules of Operation," as outlined by the State Safety Code, the craneman should be told that he must use a ladder or steps for his entrance to the crane; climbing up or sliding down girders is a dangerous practice. In addition, the following rules and points should be clearly explained:

He is not permitted to take into his crane cab any contrivance on which to sit, as the company would have provided a stool if it had not been proven to be impossible for a craneman to obtain a full view of those underneath him while he is sitting. Also, he is not allowed to entertain his friends in his cab, nor is he to carry papers or magazines to his crane to be tempted to read, as his mind must be kept clear.

The craneman is held responsible for the working condition of his crane, which will necessitate a daily inspection with a weekly report on a form provided for this purpose. This report, a copy of which is reproduced here, is handed to the Superintendent at the end of the week for his approval, and then forwarded to the Safety Department.

The first duty of the craneman on entering the cab, should be to see that the controllers are in the off position, and then signal by ringing his bell and waiting a minute or two to determine whether someone may be working on the crane without having locked the switch.

Much of the responsibility in connection with the operation of a crane depends upon the judgment of the craneman, but he should have some definite rules and policies for his guidance. For example, he must refuse to move a load that he believes is too much of a lift; under no circumstances is he to do so without authority from his foreman. Also, he must never carry loads over employees. In case a man working on a runway does not step out of the way after the first alarm is given, the craneman should give a second alarm; if the man still refuses to move, the craneman may pass over him, but a second offense must be reported to the man's foreman.

Under no circumstances is the crane operator to take signals from two different sources when lifting a load that requires special maneuvering. He must wait until he has been signaled by the proper authority to lift and move. Another rule is that when lifting buckets or other vessels, at no time should two be raised at once on one chain, or even on two chains or cables.

The craneman must be made to realize at all times the responsibility of his position; that he is to be alone 20 ft. above his fellow workmen from 4 to 5 hr. at a stretch, with no one to consult; that he must learn to depend upon his own wits and common sense; that any deviation from the safety rules may lead to an accident which may prove fatal; and, that continual vigilance must be exercised.

The floormen must also be given instructions as to their part in protecting their fellow workmen, and have pointed out to them the dangers in connection with crane operation.

Although the human element, the operator, must be given especial attention and supervision, and held at least partially responsible for the condition of auxiliary equipment, such as chains and cables, it is well to employ an inspector for this work as a check and as a definite insurance that the inspection is carefully made. In addition, prizes are sometimes given to those who may find defective links that have escaped his notice. Where this inspection and prize check-up system has been in use it has proven to be an important incentive for alertness on the part of those handling chains and has helped to prevent many accidents.

A weekly inspection report, such as this, is made out for each crane.

C-30

CRANEMAN'S REPORT

CONDITION OF CRANE FOR WEEK ENDING ..... CRANE No. ..... DEPT. .....

CONDITION OF	REMARKS	APPROVED BY FOREMAN	ORDER No. FOR REPAIRS
CHAINS, CABLES AND HOOKS			
BRAKES			
GEARS			
END TRUCKS			
TROLLEY FRAME			
CRANE TRACKS			
TROLLEY TRACKS			
LIGHTS			
BEARINGS			
LIMIT SWITCH			
MOTOR			
CONTROLLERS			
WARNING DEVICES			
FIRE EXTINGUISHERS			
MAGNET CABLES AND PLUGS			

IS CRANE CLEAN AND FREE FROM FALLING MATERIAL .....

LAST INSPECTION WAS MADE BY ..... ON ..... 192 .....

DATE OF REPORT ..... 192 ..... OPERATOR

DATE OF APPROVAL ..... 192 ..... FOREMAN

..... SUPT.

CRANEMAN MUST HAND THIS REPORT TO FOREMAN.
FOREMAN SHOULD NOTIFY CRANEMAN OF APPROVAL OR DISAPPROVAL OF SUGGESTED REPAIRS.
SUPERINTENDENT WILL FORWARD THIS REPORT TO SAFETY DEPT

Attend the *Iron and Steel Convention* by Proxy, if you cannot be there in person

NOT all of the men who are responsible for operation of the electrical equipment in our iron and steel mills can attend the big convention of the Association of Iron and Steel Electrical Engineers to be held at Pittsburgh, June 13 to 18. It is expected, however, as heretofore when these conventions have been held in the Iron City, that a good representation from the foremost plants of the country will be on hand to listen to the papers that have been prepared and take part in the discussions from the floor.

IRON and steel men never seem to be bashful in telling what they have on their minds after the papers are read at a meeting and discussions are requested from those present. For this reason the discussions give a man things to ponder over and are far from the "Yes, sir, I agree" comment that fails to bring out any of the points that might be added to a paper when there is full and free discussion.

THE program this year has been carefully prepared and the topics cover the larger problems of operation common to most plants, so that every suggestion will deserve careful study from the standpoint of adopting all or at least that part which can be used with benefit. Even though the benefits are not apparent at once, the suggestions will come from such important plants that they deserve trial and experimentation before being passed by as good for somebody other than yourself.

FOR those who have to stay at home, the members of our editorial staff and I will attend and report in detail those things that come up in which you will be interested. In other words, you will have decidedly interested representatives at this convention so that when you get our July issue you can sit down by yourself and go into convention alone with much profit if you follow this suggestion:

YOU will find in referring to the papers and the discussions on these that the names of the individuals, their positions, plant connections, and addresses will be given. When reading over these discussions, mark the sections of interest along your line of work. Then write your comments on the points brought out, from your experience in your own plant, and send them to INDUSTRIAL ENGINEER for publication. Such comments when published always draw remarks from other men, so that the benefits of this interchange of experience will be extended to many more men than could have found it possible to attend the convention.

WE MENTION this so that when you get our report number covering the convention you will not just read it and lay it aside. If you are a steel mill man or an operator in any other plant and are interested in the topics reported, make it a point to add your comments on the subject you are most interested in, and send them in as soon as possible after our July issue reaches you. In case you cannot write your comments then, they will be welcome at any time, if they come from the heart and give information based on experience with the improvements that new methods and processes have brought to the iron and steel industry.

Practical Pete

P.S. IF YOU are going to be at the convention, stop at Booth 131 and pay us a visit; let's get acquainted P. P.

INDUSTRIAL ENGINEER

Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories

G. A. VAN BRUNT, *Editor*

Save Money by Saving Time

THERE is oftentimes a strong tendency to consider the adoption of a new method or tool solely on the basis of the easily-proved saving that it will make. The desire to save as much money as possible by cutting operating and maintenance costs is entirely justifiable. One should not, however, overlook the fact that indirect savings and incidental advantages may be of more real importance than savings that can easily be expressed in terms of the dollar sign.

In his article on the use of arc welding, page 281, J. S. Murray expresses in the following words a viewpoint that can well serve as a sound basis for judging the worth of any method or equipment applicable to maintenance work:

"This is a big saving in labor, as well as in the cost of a new part for replacement. The decrease in delays to production is, however, one of the most important considerations in steel mill operation, because of the importance of each piece of equipment in the production routine. Equipment that is idle for repairs is not making steel."

Idle equipment represents idle invested capital and productive capacity. This fact should be sufficient justification for the purchase or use of anything that will help to prevent breakdowns, or save time in getting equipment back into service in the event of failure. The question of how much money it will save in so doing, as compared with other methods, is of secondary importance.

Putting Method into Maintenance

MEN supervising maintenance in industrial plants are well aware of the frequency of misunderstandings in connection with telephoned requests for emergency assistance. The urgency of the situation may well justify a hurried telephone call, but it is well to remember that too much haste is likely to result in waste of both time and effort.

Two of the most common causes of misunderstanding are failure to learn just where the trouble is, and inadequate information on what is to be done. When a foreman calls in and merely leaves word to "come over and fix Bill's machine," there is a possibility of the repairman going to the wrong Bill. These mistakes waste valuable time, and the Maintenance Department is always held responsible.

Where shops are laid out in bays and sections which are identified by numbers or letters, the plan of requiring that these identification marks be given will save trouble. In any case the department name or number, floor number, and other identifying marks can be required.

Inadequate information as to the nature of the trouble is probably the greatest source of lost time in making repairs. For this reason, it is the rule in one plant not to send a repairman until as much information as possible is obtained over the telephone. It is said that in more than 90 per cent of the cases he is able to take enough tools and supplies to make the repairs needed. Before this plan was inaugurated he had to make two or more trips about 90 per cent of the time.

It is advisable, of course, to avoid undue complication of routine and procedure, but any plan that will help to organize maintenance work on a more efficient basis is well worth serious consideration.

The World Has Diagnosed Its Economic Ills

A FEW days ago an intrepid young aviator slipped a couple of sandwiches into his pocket, climbed aboard his airplane, and in less than 36 hours was asleep in Paris.

Any American business man can now call up and talk to a customer in England, say, with little more ceremony than would be involved in calling up his own home, or a friend down the street.

With the rapid annihilation of distance as an obstacle to travel or communication, there has grown up a marvelous structure of international business. Mighty as this structure is, it is, nevertheless, so delicately balanced that comparatively small changes in conditions may have far-reaching effects. European nations are facing many serious problems and, whether we will or no, the successful solution of these problems is certain to mean much to our own prosperity, as well as theirs.

It was fitting, therefore, that the International Economic Conference should have been called under the auspices of the League of Nations to consider means of hastening the revival of prosperity in Europe. This conference adjourned a few days ago. Reports from E. J. Mehren, one of the vice-presidents of the McGraw-Hill Publishing Company who has been covering the conference for the McGraw-Hill publications, indicates a goodly measure of accomplishment.

Among other things, the delegates recommended the removal of hampering trade barriers, declared the value of an efficient industrial organization as an aid to economic recovery, considered the function of international industrial pools, and urged international statistics that should result in more intelligent management for industry and agriculture.

Of special importance was the declaration that Labor should co-operate in the reconstruction program. How much more rapid would our own scientific management movement have been if Labor had always been party to it! Europe, about to begin an intensive study and application of all devices for reducing costs, has started in the right way by getting the help of the workers.

Accord was established on many important points, which is a necessary step for effective action. Probably the most notable commerce recommendation is tariff stabilization, making long-term contracts possible. Highly commendatory are the recommendations for the collection of world statistics on raw materials and agricultural products, and studies of basic materials in which a world shortage is most feared. Intelligent world economy in industrial and agricultural production and marketing is not possible without such figures and studies.

Aside from these definite recommendations and conclusions, much good has been done. The world now has a clear understanding of its economic ills and knows what the ablest specialists think are the remedies therefor: thus a basis for action has been laid. Although quick results must not be expected, as the problems are large and complicated, this conference would seem to have justified its being.

Special Belts Are Solving the Problem of the Narrow Pulley

ONE of the most common methods of meeting the demands for increased production is to increase the speed of the machine and at the same time take heavier cuts with tools that have been designed to stand the heavier load. Often after these tools are installed it is discovered that they cannot be operated at the expected capacity because the pulley width will not permit the use of the wider belt which is necessary.

Oftentimes an attempt to use an ordinary double belt does not meet with much better success because the diameter of the pulley is so small that the heavier and stiffer belt does not bend so readily and give the necessary adhesion to the small pulley. Also, in order to get the increased speed, the diameter of the driving pulley is usually increased, which decreases the arc of contact on the machine pulley and makes the drive more difficult for the heavier belt.

Belt manufacturers are meeting this problem by providing special belts which are heavier and also more flexible than those made from leather of ordinary tannage. Belt users are finding these especially adaptable where demands for an increase in power transmitted are limited by pulley sizes or the arc of contact obtainable.

Operating men who are having trouble with such drives may find it to their advantage to ask the belt manufacturers for their recommendations.

Why Fan Static Should Be Accurately Determined

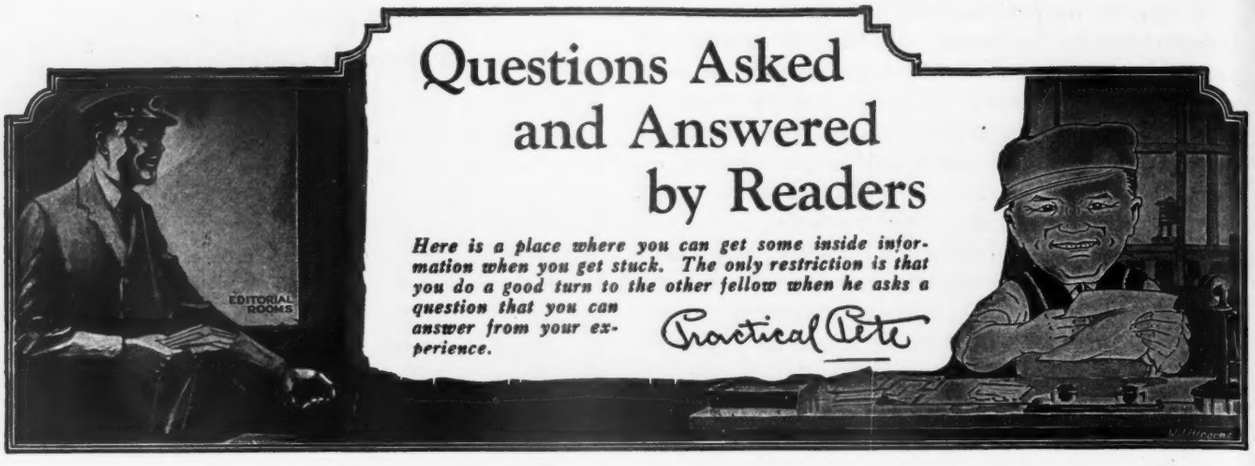
BLOWER and exhaust fans have been used for so long that certain rule-of-thumb practices have been adopted for selecting the sizes of motors required. Most of these rules are the seat of trouble at some time. This is particularly true of the one by which motor horsepower is specified as 50 per cent more than the brake horsepower of the fan or blower. In many cases this results in an induction motor operating at low power factor and reduced efficiency when the fan is properly adapted to its duct system.

The bugbear in these rules of guess is the static pressure under which a fan may be assumed to operate. Static pressure is the compressive pressure existing in air or any liquid and is a measure of its potential energy. It is usually measured in inches of water. It is the means of providing flow of air and maintaining it against the friction between the moving air and the duct surface. When a motor rating in horsepower is selected for a definite static pressure and fan wheel speed and the fan has a pressure characteristic or curve that slopes downward on both sides of the 100 per cent capacity point, the operation of such a fan at a lower static pressure than assumed, without a reduction in speed, increases the volume of output and calls for a marked increase in the horsepower of the motor.

When the rated motor horsepower is close to the brake horsepower of the fan, the overloading of the motor when direct-connected may be enough to burn out the windings. In any case it will cause overload relays on switches to trip frequently and cut the fan out of service, with the result that some operator may find fault with the relay settings and put them beyond the point of safe protection for the motor.

In the case of a belted fan unit there is much more leeway in correcting a bad guess in static pressure. The easiest method is to increase the size of the fan pulley, so that the volume of air from the fan is brought down to that corresponding to the actual static pressure. This requires a knowledge of the fan characteristics and efficiency, and a check on the static pressure with a pitot tube. The use of such a device in correcting motor overloading is only a relief for the situation. The correct procedure is to calculate the static pressure carefully when the fan installation is laid out, so that both fan and motor will be suited to the job at hand. A little time spent then may prevent much serious trouble later.

Guesswork in connection with blower and exhaust fans of the housed type, either as to capacity or motor horspower required, is a very troublesome tool, even when used by those who have had considerable experience in ventilation work.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

QUESTIONS

Who Can Answer These?

Loading Synchronous Motor to Improve Plant Power Factor

The total load on our plant is 566 kw., at 75 per cent lagging power factor when a three-phase, 440-volt, synchronous motor is pulling 105 amp., from the line, with the excitation adjusted for 90 per cent leading power factor. Will some reader tell me what the plant power factor will be if the synchronous motor load is increased to 300 amp., and the excitation adjusted for 90 per cent leading power factor at this load?
Cleveland, Ohio. B. E.

Parallel Operation of Alternators

We are considering the operation of a high-speed, steam-turbine-driven, 500-kva. alternator in parallel with a 3,000-kva. alternator driven by a low-speed, hydraulic turbine. Will readers kindly tell me what difficulties, if any, will be experienced in synchronizing and cutting the alternators in on the lines? During parallel operation under different load conditions, what troubles are we likely to encounter? Also, will any special governing device be required? W. A. P.
Smooth Rock Falls, Ont., Can.

Can Formation of White Incrustation on Brick Be Prevented?

Our main office building is built of pressed red brick, most of which is covered with a white, salt-like incrustation that is very unsightly. Part of this can be brushed off, but it soon forms again. We do not want to paint the building if it can be avoided and I should like to know if there is any treatment that can be applied to the bricks that will prevent the formation of this white coating.
Chicago, Ill. R. P.

Maximum Economical Size of Motor for Group Drives

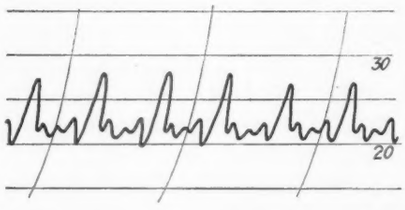
We have a number of group drives operating screw machines, lathes, and so on, the driving motors ranging between 20 and 40 hp. Installation of new machines will make it necessary to replace two 40-hp. induction motors with larger ones, or to split these two drives into smaller groups. I understand that some plants will not use a motor in excess of 35-hp. rating on a group drive, the group being split up when the power required exceeds this figure. I wish that some readers would let me know what their policy is on this point, and tell me how they determine the maximum economical size of motors for group drives. That is, when should a group drive be split up instead of installing a larger motor to take care of increased power demand?
Moline, Ill. W. B.

Scott Connection for Multiple-Circuit Motors

I will have to reconnect a number of four-, eight- and ten-pole, two phase, motors for three-phase operation and wish to use the Scott connection, but can find directions and diagrams only for six-pole, series-connected motors. Will some reader tell me how to use the Scott connection on motors having two, three and four circuits?
Philadelphia, Pa. R. I. G.

Interpretation of Graphic Meter Record

I have run several tests on a gear-driven duplex plunger pump and should like to know why the graphic wattmeter records are as shown below instead of being a straight line, thus indicating a steady power input. The cranks on opposite



sides of the gear are set at 90 deg. Will readers please tell me whether such a chart is normal, or is due to defects in the meter, or in the pump or motor. Also, can graphic meter records be used to detect or locate pump troubles?
Detroit, Mich. S. B.

What Causes Spotting on This Commutator?

We are having trouble with a 200-kw., Type HCC G.E. rotary converter which was rewound about a year ago. This machine ran perfectly until three months ago, when it began sparking at the brushes, and black spots formed in three places equally distant around the commutator. The mica is not high because we have stoned this commutator three times in the last three months, and in addition have checked the winding for open circuits. Will some reader kindly suggest a remedy for this trouble?
Logan, W. Va. F. H.

ANSWERS

Received to Questions Asked

Cause of Short Life of Lamps

In our knitting department there are many belts, every other one being crossed. The wiring for the lighting system in this department is enclosed in conduit, which is grounded. I am using the No. 622 Holophane lighting unit, which is a glass reflector. Although I have used both 110- and 115-volt, A 23 and PS 25 lamps, respectively, on a circuit that indicates a constant voltage of 106 volts on a recording voltmeter, the lamps in these units last only about 100 hr. I shall appreciate any information that readers can give me as to why our lamps have such a short life, and how I can remedy this condition.
Newton, Mass. D. C. S.

IN REGARD to the question by D. C. S., if these lamps are near moving belts, the static electricity induced by the belts will cause trouble with lamps.

I once had a similar experience, in which the lamps were short lived due to static electricity on high-voltage busbar structures. It was found that by inclosing the bulbs in an ordinary wire lamp guard and grounding the guard to the conduit, the life of the lamps was increased considerably.

While I cannot state positively that this suggestion will remedy D. C. S.'s trouble, I believe it would pay to try it out by purchasing a few wire lamp guards. After inclosing the lamps that are giving trouble, ground the guards to the conduit. If this method is tried out, I shall like very much to know the results obtained.
Dallas, Texas. A. L. TUFFLY.

IN ANSWER to the question by D. C. S., his trouble appears to be caused by vibration. If the recording voltmeter is correct, the A 23 and P. S. 25-watt lamps should give a normal life, provided there is no other trouble.

It might be advisable to obtain the old Type P. S. 25-watt lamps as they stood considerable vibration. The P. 19 mill-type lamp would probably work better in this case if they were

made in a 100-watt size, but I do not believe that they are made larger than 50 watts.

Trouble from vibration may also be lessened by using a short piece of reinforced cord between the outlets and sockets.

J. A. BANTAU.
Los Angeles, Cal.

IN ANSWER to the question by D.C.S., our experience with such troubles has proved that they can ordinarily be overcome by using either an Edison Mazda B mill-type lamp, which is obtainable only in the 110-volt, 50-watt size, or the type of lamp that is generally used by street railway companies. These lamps are used five in series on a 550-volt circuit and are rated at 95 watts. In case these lamps are too small for D.C.S.'s use, it will be necessary to either devise or purchase some sort of spring to suspend the lighting units in order to absorb the vibration, which I believe is responsible for the short life of the lamps.

The Martindale Electric Co., Cleveland, Ohio, can furnish what are known as cushion hooks to cure such troubles. These hooks are for use in suspending Mazda and Type C lighting units in connection with supports and hangers. The cushion hook is made of heavy stamped steel formed about a spiral spring from which the fixture hangs, the hook serving as a combination suspension and shock absorber, thus protecting the lamp from jars and vibration which would likely result in damage to the filament.

H. J. ACHEE.
District Line Supt.,
Southwestern Light & Power Co.,
Elk City, Okla.

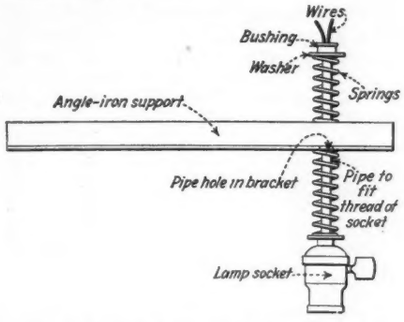
ABSENCE of definite information as to the location of D.C.S.'s lamps as regards their proximity to belts, and whether they are suspended so as to eliminate vibration or not, makes the solving of the problem rather difficult. No definite information is given as to whether the trouble is confined to one particular area, or whether it is spread out over an area that includes all the lamps. However, I will enumerate some of the troubles I have encountered with lamps and the manner in which the trouble was corrected.

D.C.S. states that the wiring is enclosed in conduit and I assume from this that the sockets are suspended from drop cords. In this case little trouble should be experienced from vibration. However, in cases where the floor above is occupied by machinery that causes considerable vibration, trouble may be experienced. In cases where trouble of this nature is encountered the best remedy is to suspend the sockets on a spring attached to the ceiling, as shown in the accompanying diagram.

There is a remote possibility that static from the belts in the knitting department is causing the trouble. I have in mind one case where static from a belt seemed to affect the filaments to such an extent that the lamps burned out after a few hours' use. To stop the trouble from this source a grounded wire was run parallel with the offending belt.

ARCHIE L. FORGER.
Chief Electrician,
The G. A. Head Electric Co.,
Laconia, N. H.

REFERRING to the question by D. C. S., I presume he has examined the lamps for clues to the cause of the trouble, although he does not mention them.



This shows how a lamp may be supported to eliminate filament breakage due to vibration.

Blackened lamps, with an occasional white opaque one, are signs of over voltage, whereas broken filaments show that vibration is causing the trouble. From his description I believe that vibration is causing the trouble.

I recently saw in one of the engineering magazines a diagram of a spring hanger for supporting lamps, similar to the one shown in the accompanying illustration. Another spring lamp similar to the one that I have just described is illustrated in an article, by O. C. Callow, entitled "Cutting Costs of Operating and Maintaining Lighting Systems" on page 67 of the February issue of INDUSTRIAL ENGINEER.

H. D. FISHER.
Plant Engineer,
New Haven Pulp & Board Co.,
New Haven, Conn.

ANSWERING D.C.S.'s question, I had a similar experience with lamps that were short-lived. These lamps were operated among a large number of endless glued belts that ran over wooden pulleys. The short lamp life was due to the static electricity generated by the belts. The lamps in this case lasted from 48 to 96 hr. which is not very long.

The trouble was remedied by installing a copper wire comb, made of No. 18 and No. 8 wires, close to the belt. This arrangement eliminated the trouble from short lamp life.

If glass reflectors are used in D.C.S.'s installation, I would expect more trouble with the lamps than if metal reflectors were used and grounded.

One way of determining whether static is causing the trouble is to make a turn of No. 18 wire around the glass lamp globe and then fasten one end of this wire to the conduit at a spot that has been scraped clean just above the condulet or socket.

Static may also be produced by the knitting machines. In this case ground the machines, and then run a copper wire close to where the threads pass from the spools to the machines. I shall be interested to learn how D.C.S. eventually overcomes his lamp trouble.

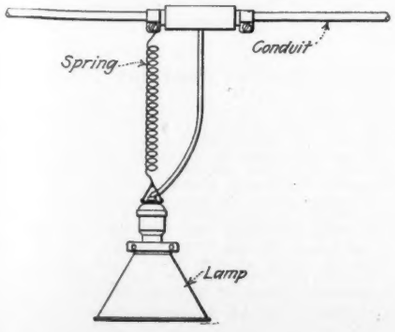
WM. KOEPERNIK.
Foreman of Electricians,
The Larkin Co., Inc.,
Buffalo, N. Y.

REFERRING to D.C.S.'s question, the information furnished indicates that he suspects that the trouble is due either to overvoltage or static. If he has tested the voltage and found that it is suitable for the lamp, we can eliminate that consideration.

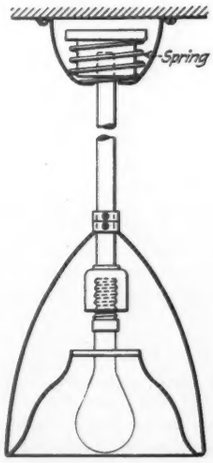
The disturbances caused by static discharges are very similar to those from lightning discharges. Although D.C.S. could test for static discharge and note the effect on the life of the lamps, I doubt if this test will lead him to a solution of his problem.

The short life of incandescent lamps in industrial plants carrying on certain operations in buildings of certain types of construction is a well-known phenomenon. It is due entirely to vibratory stresses set up in the lamps by the operation of the machines, which become aggravated when the natural period of the vibration of the filament happens to be an exact multiple of the period of vibration set up in the building. As a rule lamps do not go out while burning because the filaments are soft and pliable, but break while they are not burning.

Suspending a lamp from a long spiral spring will minimize the effects of vibration.



This shows the construction of a lighting fixture designed to eliminate lamp vibration.



The remedy for this trouble is the installation of shock absorbers, such as Type UNJC or Type H, manufactured by Crouse-Hinds Co., on the fixtures. These shock absorbers are inexpensive and easily installed.

I would suggest that D.C.S. equip about ten of his fixtures with shock absorbers similar to the one shown in the illustration and then report the results of this test to INDUSTRIAL ENGINEER for the benefit of other readers. The cost of equipping fixtures with shock absorbers should not exceed $1.50 per fixture. E. OGUR.

Consulting Engineer,
New York, N. Y.

IN REPLY to the question by D. C. S., assuming that the voltage indicated was correct, I would blame the cause of the trouble on vibration. If vibration is causing trouble with the lamps, the use of modern spring fixtures will materially increase their life.

It is possible that the lamps are being periodically crossed with higher voltage leads, for as the lamps he mentions are burning at 84 and 61 per cent efficiency, respectively, this fact would ordinarily indicate that they should last longer.

For mill service it seems to me that I would use a mill-type lamp in place of the present lamps for they are better adapted to such service especially if vibration is decreasing the life of the other type lamps. To increase the lamp efficiency I would recommend raising the lighting-circuit voltage to the normal rating of the lamps. E. J. MORRISSEY.

Chief Electrician,
Western United Gas and Electric Co.,
Aurora, Ill.

What Is Best Kind of Insulation for Semi-Closed Slot Motors?

I shall appreciate it very much if readers will tell me whether it is better practice to use varnished cambric between each coil in a semi-closed slot motor, thereby insulating each coil from its neighbor, or to tape each coil separately and then use insulation only between phases.
Rome, Ga. M. S. C.

REGARDING M.S.C.'s question, the following will describe some methods used to insulate the slot and end sections of partly closed slot motors, the slot sections being considered first:

The first method requires a bent winding cell with lips or three bends, as shown in Fig. 1, the bottom slot being a snug fit for the slot; the overhanging top ends or lips should leave the opening unobstructed.

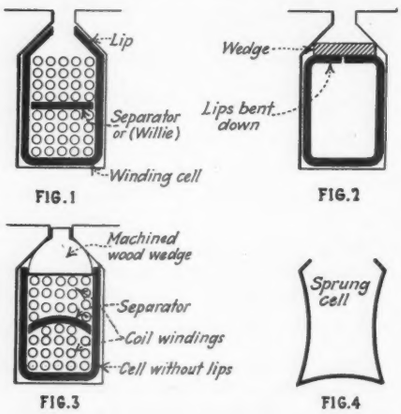
When only one cell is used, it must be a combination slot-insulation material at least 0.023 in. thick. This material has a fishpaper base with treated cloth cemented to it, thus resulting in a cell having good mechanical and dielectric strength. The cells should be at least ¾ in. longer than the core and the fishpaper placed against the iron.

Next, a fiber separator, which is used between the top and the bottom coil halves, can be 1/32 in. or 1/16 in. thick depending on the slot room. It must be a snug fit width-wise in the slot, not so tight as to cut the cell, but close enough to bind and hold the bottom coil half down. When tamped with a tee drift and mallet, the separator should also be at least ¾ in. to 1 in. longer than the length of the top coil half. This extra length insulates between the top and bottom layers of coil ends at the point where the clearance is smallest and where the difference of potential is high.

After both coil halves are in, a 1/16-in. fiber wedge, cut wide enough to make a driving fit and long enough to project ¼ in. on each side of the core, is driven in, the lips being folded over under the wedge, as shown in Fig. 2.

This type of cell prevents the wires from getting between the core and cell at the top and must be used when the slots are well filled, or when the winding is within 1/32 in. of the bottom of the tooth overhang.

Fig. 3 shows the second method, in which a combination slot insulation cell without lips is used, the separator being of the same material and guttered or dished as shown. The wedges are hard wood (maple) and machined to fit the upper slot. It is highly important that the bottom section of the wedge be a snug fit inside the winding cell as shown, and the bottom of the wedge must be at least 1/32 in. below the top of the winding cell. This last type of cell requires more care in driving the wedges as the wires are likely to get between the cell and the iron.



This shows how coils in semi-closed-slot motors should be insulated.

The first method is the best for general repair use, the only disadvantage being the two extra bends for making the lips. Fig. 4 shows how the cells should be sprung before placing them in the slot. This opens them out and keeps the lips open and the cells stiff. All bends should be made parallel to the grain of the fishpaper.

If a plain paper winding cell is used, an 0.007-in. or 0.010-in. treated cloth cell must be used for both the bottom and top coil halves; that is, two cells are cut and turned over their respective coils and the separator should also be used, as the wires are likely to work up between the folded cells.

There are about four methods of insulating the coil ends, but the first two are for use onlv when the motor is in a clean location, free from metallic dust, grit, and the like.

(1) With this method the coil ends are not taped, but triangular pieces of 0.010-in. treated cloth are put between the coil ends, two thicknesses being used at the point between two pole-phase groups for phase insulations. This is a quick and satisfactory method for motors that are to be used in clean locations.

(2) This method is the same as (1) except that the last coil of each group is taped with one overlapping layer of 0.007-in. cotton tape from cell to cell, and one triangular strip is put between the coils. This is a more positive phase insulation and it is also easier to identify the phase groups.

(3) This method calls for all coil ends to be taped with one layer of 0.007-in. cotton tape, with one strip or triangular piece of treated cloth between the beginning and ending of adjacent phase groups.

(4) This is the same as (3) except that the last coil of each pole-phase group is taped with one layer of 0.010-in. treated cloth tape and one layer of cotton tape.

Method (3) is preferable to the first two, for it is quicker and the triangular strip or butterfly, as it is called, also provides insulation between the top and bottom layers of coil ends, besides helping to mark the phase groups, which helps in connecting. The last two methods should be used for motors operating in dirty places or where metallic dust, oil, grit or the like are present.

All the above windings should be given at least one dip in a good, black plastic baking varnish the number of dips being increased to suit the application.

A good combination for repair shop use and clean applications is to insulate the slots as shown in Fig. 1 and treat the coil ends as described under method (2). For other applications where dirt, oil, metallic dust and other foreign substances, are present, use the method shown in Fig. 1 for the slots and the procedure under method (3) for the ends.

The slot insulation outlined above is satisfactory for 110-, 220- and 440-volt motors, but for 550 volts, treated cloth cells should be used in conjunction with the combination slot insulation.

A. C. ROE.

Renewal Parts Engineering Dept.,
Westinghouse Electric & Manufacturing Co.,
East Pittsburgh, Pa.

Substitute for Shearing Pins

We have a conveyor line which is driven by a 3-hp. motor through a worm reduction gear. A coupling with a shearing pin is placed between the conveyor and reduction gear for protection when the conveyor becomes clogged, which it frequently does. Some time is required to replace the shearing pin and I wish to eliminate it if I can. Could a clutch be used that would slip and thus absorb the shock when an excessive load comes on, as is the case when the conveyor becomes blocked.
Youngstown, Ohio. J. L. B.

IN REPLY to the question by J.L.B., he does not state whether the pin is to protect the gear or the motor. If it is the latter and the motor is adapted to across-the-line starting, a push-button starter equipped with thermal overload relays will clear the motor from the line before it becomes dangerously hot and allow it to be started up again as soon as the conveyor blockade is cleared and the relay reset.

Control devices, that are adapted for this sort of service are manufactured by the General Electric Co., The Cutler-Hammer Manufacturing Co., Industrial Controller Co., and several others.

Vancouver, B. C. L. E. DUNHAM.

ANSWERING J.L.B.'s question, the simplest way to solve his problem would be to substitute some form of overload electrical protection in place of the protection afforded by the shearing pin. Most likely this shearing pin can be replaced by a stronger one, or the parts in which the pin is inserted can be bolted together so that in the future the overload protection of the conveyor will be at the motor. Obviously, if the conveyor clogs, the motor load will increase and the current rise immediately. The new style of across-the-line starters with temperature overload protection would be admirably suited for such an application. These devices are made by several concerns including the General Electric, Cutler-Hammer, Industrial Controller, Allen-Bradley and other companies.

All of these devices work on the same principle: namely, push-button control operating a magnetic switch. In series with the solenoid of the switch are the contacts of the temperature relay, the coils or operating parts of which are in series with the motor circuit. If the motor current rises above a certain fixed value, the relay opens the circuit. To start the motor again the relays must be set and the start button pushed. This operation will take only a few seconds. Of course, the greater the overload on the motor the quicker the relays will act. This same switch will also protect the motor against no voltage and single phasing.

Although emergency stop buttons can be placed at various points along the conveyor, it is advisable to start the motor from only one point.

I have in mind an installation of a train of conveyors with a crusher located at one end and a sorter at the other, in which all of the motors are equipped with the type of switch previously described. The motors vary in size from 3 to 50 hp. The switches are interlocked by supplying the solenoid coil of the switch controlling the second motor with current from the motor leads of the first motor switch, the third switch coil being supplied from the leads of the second motor, and so on. The coil of the first motor switch is put in series with a number of stop buttons located at various points along the conveyor. Pressing any one of these buttons stops the first motor, thus causing the coil of the second motor switch and all the other coils, to be de-energized, so that all of the motors are stopped immediately.

An overload on the first conveyor motor, such as a blocked belt, will cause the overload relays to open and stop the motor. The crusher switch just below it, being fed from the first conveyor motor lead, will then fall out, stopping this motor. Thus the crusher is automatically prevented from piling a load on the conveyor after it stops.

To sum up the advantages of this method of control J.L.B. can, at slight expense, have at once satisfactory overload protection, low-voltage and single-phase protection and a means of stopping his motors from any desired points.

Manchester, N. H. GARSON A. REESE.

Polarity of Interpoles

I do not thoroughly understand the rule governing the polarity of interpoles and wish someone would explain how it works out under different conditions. For example, on machines that have two interpoles, I have often found them to be of opposite polarity. Was this polarity correct? Can one rule be made to apply to a motor having any given number of main poles and interpoles? I shall be grateful for your help on this question.

Mohiland, Utah. K. W. F.

IN ANSWER to the question by K. W. F., the following rules hold good for checking the polarity in different types of machines: To determine the proper polarity of interpoles for a motor, proceed from pole to pole around the frame, in the direction of armature rotation. Each interpole should have the same polarity as the main pole which just precedes it, as shown in *A* of the illustration. In the case of a generator, each interpole should have a polarity opposite to that of the main pole which just precedes it, as shown in *B*.

Some types of motors and generators have one interpole per main pole, as *A* and *B*, whereas others have one interpole per pair of main poles. Diagrams *C*, *D*, *E* and *F* in the illustration show the polarity of interpoles of two- and four-pole motors with one interpole per main pole and one interpole per pair of main poles, respectively. In *C* the interpoles which are directly across the frame from each other are of opposite polarity, whereas those in *D* and *F* are of the same polarity.

Some manufacturers use only one-half as many interpoles as could be used, and by so doing use less iron and copper in the construction of the machines, claiming that this makes for a cooler machine in that it gives better ventilation, and that it reduces the cost.

On some small motors where the interpole winding has become damaged I have cut out the interpole entirely, and kept the motor in service while we were rewinding it.

I believe that if K. W. F. will study the accompanying diagrams carefully he will understand why the polarity of the interpoles was the same in some cases, whereas in other cases it was opposite. J. W. BANTAU.

Los Angeles, Calif.

PROBABLY K. W. F. has operated motors or generators which were not fitted with interpoles. If so, he knows that it is necessary to shift the brushes of such machines forward in the case of a generator and backward in the case of a motor, in order to obtain satisfactory commutation under load. The reason for this shifting of the brushes is to bring into a magnetic field of the proper polarity, those coils of the armature winding which are undergoing commutation. With a generator the brushes are shifted forward; hence the proper polarity for commutation is the same as that of the next successive main pole in the direction of rotation. In a motor the correct polarity, as the brushes are shifted backward, is the same as that of the preceding main pole in the direction of rotation.

In an interpole motor or generator, instead of shifting the brushes they remain on the neutral, and a portion of the proper main pole, so to speak, is brought to the proper position with respect to the coils undergoing commutation.

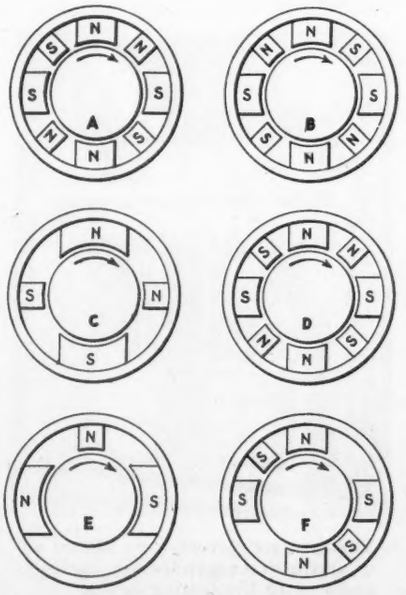
Consequently, in all motors fitted with properly-connected interpoles the polarity will always be as follows, proceeding around the commutator in the direction of rotation, N-n-S-s-N-n-S-s.

In an interpole generator the sequence will be N-s-S-n-N-s-S-n. In these arrangements, capital letters indicate main poles, and small letters, interpoles.

In machines using fewer interpoles than there are main poles, these interpoles which are used will always have the same polarity as they would if the full number of interpoles were used. Thus, the answer to K. W. F.'s other question as to the correctness of polarity he has observed when only two interpoles were used, will depend upon the arrangement of the interpoles. He can check the polarity, however, by the above method. J. M. WALSH.

Assistant Chief Engineer,
Gurney Elevator Co.,
New York City.

This shows the proper polarity of interpoles with respect to field poles and the various combinations employed.



Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Importance of Skin Effect in Overheating of Cables

THERE was considerable discussion in the Question and Answer section of the March INDUSTRIAL ENGINEER about a question signed E.M.D., Bellingham, Wash., regarding the heating of some heavy cables. In this discussion, it struck me as rather peculiar that no mention or suggestion of any kind was made regarding skin effect. The increase in the resistance of a 1,000,000-circ. mil conductor at 60 cycles due to skin effect would be approximately 9.6 per cent, whereas the increase in the case of a 2,000,000-circ. mil cable would probably be nearer 25 per cent.

When large, round conductors are used for low-voltage, heavy-duty alternating-current service, it is generally considered good practice to use rope core cable and many of the large companies recommend its use for cables of 750,000-circ. mil area and larger.

Skin effect is quite commonly confused with self-induction, but although it is primarily caused by the same magnetic field, it is not in any other way identified with it. As voltage drop and loss of energy are the results of such skin effect, this is by no means a negligible factor in cables of the size under discussion. It has no doubt, contributed its share in the degree mentioned, together with the other factors brought out in the discussion.

Lawrence, Mass. B. W. SCOTT.

Method of Locating Grounded Coil in A. C. Generator

RECENTLY a grounded coil in a 750-kw., 2,200-volt, three-phase a.c. generator caused disturbances in a telephone system and in a radio station in the vicinity of the plant, although there was no other evidence of this condition.

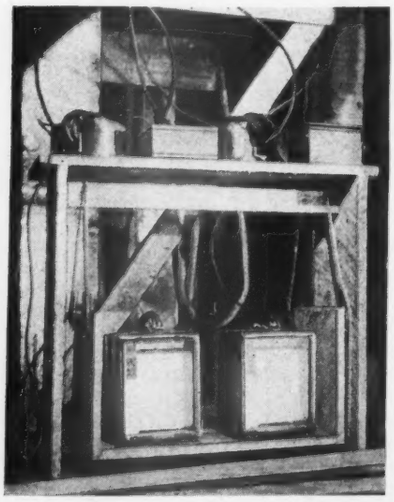
In order to find the faulty coil an ungrounded 110-volt a.c. supply circuit was connected directly to the terminals and to the frame of the alternator. This circuit drew 15 amp. on the grounded phase at 110 volts. One terminal of an a.c. voltmeter was also grounded to the frame of the alternator. The other terminal of the voltmeter was connected to an ordinary shoemaker's awl, the sharp point of which was used to pierce the insulation of the end connections of each coil in the grounded phase. A connection was made with each coil in turn and the readings of the voltmeter were noted. The coil showing the smallest reading was considered to be the damaged coil, although the voltmeter readings on three of the coils were so low that it was hard to determine which of these coils was the damaged one.

To locate the trouble more definitely, an ordinary telephone receiver was substituted in place of the voltmeter and when contact was made with the grounded coil there was no noise in the telephone receiver, but when contact was made with the coil on either side of the grounded coil the telephone could be heard several feet away. Consequently, it was very easy to find the exact location of the damaged coil, which was removed and repaired without seriously disturbing the other windings. HARRY J. ACHEE.

District Line Supt.,
Southwestern Light & Power Co.,
Elk City, Okla.

Supporting Graphic Meters to Overcome Vibration

IN A PLANT where it was necessary to run an extended test that required the use of graphic meters, it was found that the first records were of little value, due to vibration transmitted to the pens of the meters. In order to overcome the effects of vibration, it was decided to suspend the meters on springs.



The graphic meters were placed on a platform suspended on springs, underneath the testing bench.

For this purpose a test bench with a top large enough to accommodate the remainder of the testing equipment, was set up as shown in the illustration. A strip of wood was nailed between the legs of the bench and a platform of the proper size for the graphic meters was suspended from the strip by means of two pieces of window chain, to each end of which spiral springs of suitable strength were fastened.

There was no further trouble from vibration and when the test was concluded the chains and springs were salvaged for future use in tests of this nature. W. L. STEVENS.

New Westminster, B. C., Can.

Simple Tests for Determining Condition of Transformers

DEFECTS in transformers are often very apparent, but there are many times when it is necessary to employ some method for testing the condition of such equipment. Before testing the coils electrically, it is well to inspect the transformers on the outside, to see if the leads are intact and their insulation is in good condition.

First, check up all porcelain bushings to see if any are cracked. If not, they should be firmly fastened in the compound which holds them to the case. Also, inspect the leads to see if they have been siphoning oil. In case they are oil-soaked, replace them with new leads that have had a length of insulation cut away so that it will terminate above the oil level. After sweating the strands solid for several inches back from the end of the wire, tape with varnished cambric to stop the oil from creeping up the insulation again.

Ordinarily oil leaks are very objectionable and as the oil used in transformers has a great tendency to leak through the threads in the casing, it is best to inspect carefully all plugs, drain cocks, oil level gages and thermometers for signs of oil leaks. Leaking threads can generally be put in good condition by taking out the conduit or plug that is giving trouble and running the threads over with a die. The tapped hole in the casing can then be cleaned out with a tap. Before replacing the plug or conduit, cover the threads with white lead, litharge and glycerine, thick shellac, or even LePage's glue which has been used successfully for keeping the joints tight. In any event, whatever is applied to this joint should be allowed to dry thoroughly before subjecting it to oil; otherwise the oil is very likely to seep through it.

An electrical ground test should now be applied to the low-voltage side of the

transformer. The testing current should be applied gradually and brought up to the point where its voltage represents twice the rated voltage plus 1,000, the highest voltage being applied for 1 minute.

The high-voltage side of the transformer should now be tested to ground. In this case, it is generally necessary to employ unusually high voltages; consequently it is necessary to take extra precautions to safeguard those running the test.

In our repair shop we make use of a 30,000-volt, Type K, General Electric transformer for testing transformers and oil samples. This test transformer has a small voltage regulator on the low-voltage side that can be connected to the 110-volt or 220-volt a.c. supply. Thus it is easy to raise the voltage slowly, step by step, from zero to 30,000.

When making a ground test on the primary side the test leads should be connected to all primary leads in sequence, and the other leads can be connected alternately to the core and to the transformer case. During this test the secondary leads should be grounded, in order to avoid any stresses that might be set up in the windings. In case the transformer is very old, it will be best, however, to reduce the test voltage somewhat.

The next check will be between the primary and secondary windings. This test is carried out by connecting one test lead to the primary wires and the other to the secondary wires. The highest test voltage in this case should also be continued for one minute. Before making this test be sure that the windings are clean and, above all, dry. If in doubt about this, use a Megger and measure the insulation resistance of both windings. If the reading is low, the coils should be dried out, and another reading taken before applying the high-voltage test; otherwise the windings are likely to be damaged.

After these ground tests have been made, it is well to measure the ratio of the transformer. This will show whether the windings are intact, and also whether any sections of the windings are shorted. Ordinarily we find it easier to apply voltage to the low-voltage side and measure the output high-voltage side with a potential transformer and meter. In this case the readings of the primary and secondary should agree with the voltage ratings on the nameplate.

When it is possible to do so, it is well to give the transformer the following insulation test: Use double the rated frequency and apply voltage gradually to the low-tension windings of the transformer, building up the voltage until it reaches twice the normal voltage. The higher frequency has a tendency to keep the current from exceeding the rating of the coil. This test subjects the insulation between adjacent turns and layers to twice its usual voltage and should show up partial shorts, poor insulation, and the like. In making this test one should always have the protection of circuit breakers or fuses in the circuit ahead of the testing apparatus in order to protect it and the apparatus under test.

If it is desired to apply the full-load current to the secondary windings, connect the secondary terminals through an ammeter and then apply a low voltage to the primary windings. Raise this voltage gradually until the ammeter indicates that rated full-load current is flowing. During this test, one can tell if the transformer heats while operating under full load. Also, this is a good way to dry out the windings if the transformer has been idle.

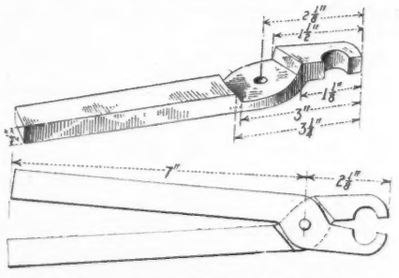
Whenever applying full-load current to the secondary, it is absolutely necessary that the transformer case be filled with oil. Trouble often results if the dielectric strength of transformer oil is not kept up to the proper standard which has been set at a value of 22,000 volts with 1-in. disks spaced 0.1 in. apart, or 40,000 volts with 0.5-in. disks spaced 0.2 in. apart.

EDWIN W. LINDOP.

Los Angeles, Calif.

How to Make Inexpensive and Durable Fuse Puller

ALTHOUGH fiber fuse pullers can be purchased, many electricians prefer to make their own. Some idea of the life of a home-made fuse puller may be judged from the fact that the one I am using was made by me over 13 years ago.



Red fiber is a good material from which to make a fuse puller.

The accompanying sketch gives the dimensions of a puller that will handle cartridge fuses up to 100-amp. rating. If larger fuses are to be handled, the dimensions of the puller must be increased.

It was made from ¼-in. red fiber. This was first cut to the approximate shape with a hacksaw; then the surface was smoothed on an emery wheel and later with a file. CHAS. A. PETERSON.

Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Poor Workmanship and Neglect Cause Shutdown of Plant

PRODUCTION was held up recently in a plant due to a combination of troubles in the control of a 30-hp., 220-volt, three-phase, squirrel-cage, induction motor. This motor was operated from an auto-starter. Several attempts to start the motor were unsuccessful; so we started out to locate the cause of the trouble.

First of all, the circuits were checked up for defects. Then the auto-starter was inspected. An examination soon revealed the fact that the oil in it had been allowed to become very low with the result that the contacts were not covered. These contacts were badly burned from arcing, and when the starter was operated a few contacts would occasionally make a hit-or-miss connection with the result that the motor would only hum, due to an open phase.

Nearly a day's work was required to repair the auto-starter, as no spare contacts were on hand, and upon completion of the job the same open-phase hum was evident. The wiring from the starter to the motor was again checked and it was found that one of the phase wires sometimes tested out open, and at other times, closed.

Further investigation disclosed that on the original installation of the motor the terminal lugs were bolted with lockwashers to the phase-wire lugs. When the motor was later removed to a new location, the same materials, with one exception, were used in the new installation. This exception was the lockwashers, so the whole trouble with the exception of pitted contacts in the auto-starter, was a loose connection between the two copper lugs on one phase wire. The vibration of the motor had caused the bolt to become loose and resulted in a high-resistance joint in the circuit, which became worn away by arcing until an open joint resulted. After we had made a secure joint, the motor operated satisfactorily.

NATHANIEL W. BLANCHARD.

Inwood, L. I., N. Y.

Motor Breakdown Prevented by Insulation Tests

A MOTOR which was installed near a battery room door would have run satisfactorily for several years if the battery attendants had taken the pains to keep this door closed. As the result of leaving this door open quite frequently, acid fumes from the battery room ate away the insulation to such an extent that a Megger test on the machine showed that parts of the insulation had a dielectric strength that was far below the standard for the successful operation of this motor. The cotton covering in places on the armature coils was nearly eaten away, although the field magnet coils were found to be, on the average, in better condition, due to the fact that a good shellac varnish had been applied in quantity.

As the fault was discovered in time, we were able to reinsulate the coils on the armature; otherwise we would have had a complete breakdown, which would probably have been much more costly in time and money.

Our experience with this motor indicates the necessity of making periodical insulation resistance tests and keeping a close watch on equipment exposed to acid fumes. Furthermore every effort should be made to minimize such exposure. In this case, we installed double doors leading to the battery room. Only one door is open at a time, thus reducing the possibility of acid fumes escaping from the battery room. W. E. WARNER.

Shefford, Bedfordshire, England.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Emergency Speed Reducer Built from Auto Steering Gear

INDUSTRIAL operating men who are convenient to mill supply houses and the branch offices of various manufacturers can usually be supplied without a great deal of inconvenience with miscellaneous pieces of equipment that they need.

Many plants that are operating away from the larger industrial centers, however, sometimes have more difficulty in obtaining parts in an emergency and the exercise of considerable ingenuity may be required to provide a satisfactory substitute.

One problem which we faced recently may be of interest to other men in case of a similar emergency. A small pump was to be driven by a fractional-horsepower motor. The motor was rated at 1,760 r.p.m. and the speed required for the pump was about 200 r.p.m. A belt drive could not be used because the space was too small and the location otherwise unsuited to it. It was obvious that a small reduction gear unit would do the work very well, but none was to be had on short notice in this immediate locality.

Finally the worm and worm wheel of an automobile steering gear were thought of. A visit to an auto wrecking shop disclosed the gear ratio of one such device was 8:1. This was mounted on a plank in line with the motor to make a direct-connected drive. A piece of rubber hose, in the emergency, served as a flexible coupling between the motor shaft and the worm shaft. The low speed, approximately 220 r.p.m., was taken off the worm gear shaft which extended at a right angle to the gear unit. The entire assembly operated very satisfactorily and economically solved our emergency problem.

W. L. STEVENS.

New Westminster, B. C., Can.

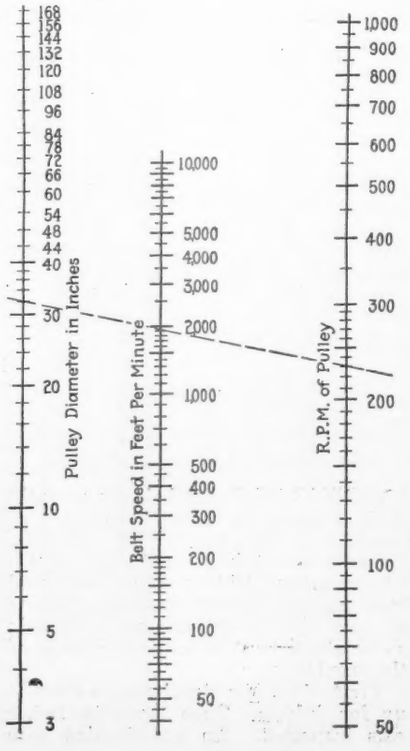
Simple Chart for Determining Belt Speed

FOR effective operation of leather belts in the transmission of power, it is always well to keep the belt speed high because the power transmitted depends upon the speed and the size of the belt. Thus, at high speeds narrower belts can be used. In any installation it is usually possible to lay out a drive for any one of a number of belt speeds because a constant reduction ratio between the pulleys may be obtained by the use of several different combinations. To check the belt speed of these combinations, operating men will find the accompanying chart very convenient. To use this chart, it is necessary to know only the pulley diameter in inches and the revolutions per minute of the pulley; both of these factors are usually known, or determined in advance.

With this chart the belt speed in feet per minute is determined by the intersection on the center scale of a straight line drawn from the point on the scale at the left, corresponding to the pulley diameter in inches, to the point corresponding to the r.p.m. of the pulley on the scale at the right.

The chart below is used as follows, for determining belt speed.

Assume that a 32-in. pulley is located on a shaft operating at 230 r.p.m. Place a straight-edge or ruler at 32 on the scale at the left and at 230 on the scale at the right. The intersection with the center scale gives the belt speed as 1,900 f.p.m. This chart was designed and copyrighted by J. E. Rhoads & Sons, Philadelphia, Pa.



This same chart can be used to determine the surface speed of pulleys in the same way.

Familiarity with Care of Bearings in Emergency Prevented Breakdown

KNOWING what to expect and what to do when the unexpected occurs are two important factors in decreasing breakdowns and other interruptions to service. Men who can train their working force along these lines very frequently give the appearance of having nothing to do much of the time.

As a matter of fact, this type of man is paid for what he knows and because he has his department so well organized that it runs smoothly without his constant attendance. Being paid for "what he knows" means knowing what to do in an emergency and doing the right thing quickly. His real value is soon demonstrated when the emergency comes and he is almost instantly master of the situation. Under such teaching the men in the maintenance crews learn how to meet unusual situations quickly and properly.

A recent happening illustrates this point, although in this case the principal figure was a man who had been shifted at his own request from the maintenance crew to an easier job as night watchman. For 4 hr. every night he had some hold-over work to perform and after that he was merely a watchman. However, he had been well schooled in maintenance work and knew enough of the operation of the equipment to handle any emergency.

The nickel plating department in this plant always keeps the tanks in operation until 9 p.m. at which time plating generators are shut down. The night man was instructed in the manipulation of the various controls, but was absolutely forbidden to remove anything from the plating tanks.

One night he heard a noise at the far end of the room near the generators. Hastening there, he saw a faint puff of smoke near the end of one machine. This, and the labored sound of the machine, told him that a bearing was hot and cutting. The natural move would have been to stop the motor driving the generator, but instead he cut out the field excitation. This permitted the armature to revolve idle, with no load on the bearings other than its own weight.

His idea was to keep the machine running because he knew that plating could be carried on by switching the tank to another machine. He also knew that if he stopped the machine with the bearing so hot, nothing could pre-

vent it from "seizing" on the shaft. If that did occur, the repair crew would find the shaft frozen fast and both the shaft and the babbitt bearing would be deeply scored.

By cutting off the excitation he first removed all the friction possible from the bearing. He then cooled it down by flushing out the bearing and well with fresh oil; this was poured in and the drain plug opened to take off the excess and any foreign matter. Later in the night he shut down the machine, but not until the bearing was cool.

In the morning the repair crew decided that they could keep the machine in service as it was, until Saturday. Thus, this man's quick thinking turned what might have been a costly breakdown into a mere routine bearing renewal.

DONALD A. HAMPSON.

Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Simple Device for Protecting Heater Units When Blower Belt Breaks

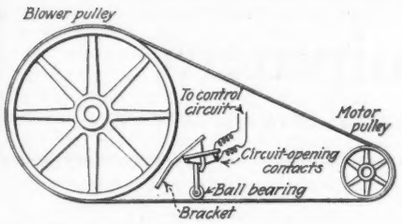
THE office building of the company with which I am associated is heated by a system of Glo-bar heating elements. A group of these elements is installed at each vent hole, and air for distributing this heat comes from a large belt-driven blower in the basement. In order to safeguard this installation from trouble that would be likely to occur at any time I made the protective device described below.

The purpose of this device is to cut out the magnetic switches connected to the circuit supplying the heating elements in case the blower stops due to the belt coming off or breaking. The motor driving the blower is operated from a General Electric 7,006 push-button magnetic switch. Energy for operating the coils on the magnetic switches controlling the heaters is also taken from the push-button switch, so that the heat is turned on whenever the motor is running.

A stop-button unit was taken from a spare General Electric compensator, and in place of the ¼-in. pin extending from it, a piece of 16-gage iron about ½ in. wide and 12 in. long, bent in a U-shape with about ⅝ in. between the sides, was installed.

A ball bearing about 1½ in. in diameter and ½ in. wide was then placed on a small shaft driven through the end of this extending arm, as shown in the illustration. A coil spring was made to take the place of the original piece of flat spring steel in the push-button unit. The original spring was too weak to withstand the constant pressure and motion that were necessary in the operation of the new unit. A small grease cup was installed on the ball bearing shaft to keep the bearing lubricated.

The whole unit was then installed in such manner that the ball bearing rides the blower belt on the inside. A bracket for holding the belt contact device was installed on the bottom of a staircase running close to the blower pulley. This device makes contact on the bottom, or the pull side, of the belt so that a comparatively uniform tension is maintained against the contact of the stop-button unit.



When the belt tension is released the control circuit of the motor and heating elements is opened.

The control circuit of the switch supplying the motor was cut open and connected to two wires run in flexible conduit to the new belt-riding contactor. If the belt should break or slide off the pulleys the tension against the ball bearing, which holds the control circuit closed, would be released, thus stopping the motor and opening the heater circuit switches.

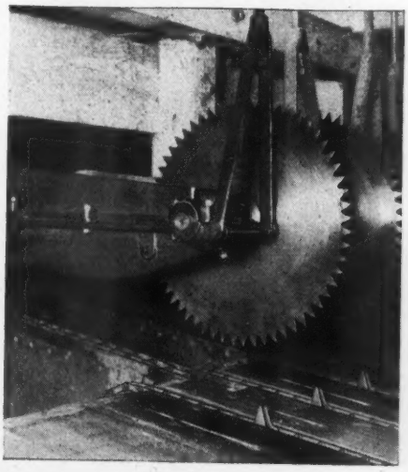
Pinedale, Calif. D. W. HAIRE.

Use of Roller Chain for Saw Trimmer Drive

THE lumber industry puts many severe tests upon the drives to the various machines that are found in the modern sawmill. Operating men in this industry are giving particular attention to these drive problems and their solution. For example. a roller chain drive, is being used on a 40-saw Prescott trimmer, recently installed in the plant of the Eclipse Mill Co., Everett, Wash., as shown in the accompanying illustration. Each drive is entirely enclosed and is in an individual casing, which also contains the oil bath in which the chain dips to lubricate both the roller joints and the sprocket contacts.

The chain used in these drives is Diamond No. 149, ⅝-in. roller, manufactured by the Diamond Chain & Mfg. Co., Indianapolis, Ind. The drive shaft sprockets have 40 teeth and the saw arbor shaft, 17 teeth; the shafts are on 2-ft. centers. The saws shown in the illustration are 20 in. in diameter and are driven at 1,900 r.p.m.

Close-up view of one of the roller-chain-driven saws on a 40-saw trimmer in the Eclipse Mill, Everett, Wash.



Compactness, positive drive features, and elimination of maintenance were, it is said, some of the reasons influencing the selection of this type of drive for this machine.

Decreasing Pulley Wear from Abrasive Dust on Belts

BELTS operating in an atmosphere of abrasive dust often grind away the pulley surface, particularly at the crown. Although it is usually considered better practice to run belts with the slack side on top, it may in such cases, be best to drive with the tight side on the top, with a resulting increase in belt and pulley life and efficiency.

Where a considerable amount of dust is flying about, particularly if this is abrasive, if the slack side is at the bottom the belt flap or vibration, which always occurs on the slack side, will tend to shake the dust off the belt and so prevent at least part of it from being carried around the pulleys and worked into the belt to wear away the pulley surface as the belt slips. All of the dust will not be displaced by the flapping, but a good deal of it will be.

When the tight side of a smoothly moving belt is at the bottom it presents an ideal place for dust to settle on. In such cases, the advantages gained by having the slack side on top are easily counterbalanced by the longer belt and pulley life and increased efficiency obtained by running the belt with the slack side on the bottom.

Easy Method of Indicating Location of Oil Holes to New Oilers

ALTOGETHER too often a new oiler or new machine operator will have to hunt out the oil holes himself when taking over his job. Those in charge often forget, even though they know that adequate and regular lubrication is very important, that the location of all the oil holes on the equipment is not known to a new operator and he may miss some owing to his ignorance of their position.

For this reason it is advisable to have the number of parts requiring oiling and their position recorded on a card hung on the machine. Generally the manufacturer of the machine supplies such a list, or a diagram or drawing showing the location of all parts that require lubrication. This could be mounted either on, or convenient to, the machine and so always be available for reference in case a new man is required to do the oiling.

I have known instances in which parts have run for some time without oil owing to the location of an oil hole not being known. Fortunately, the results were only increased wear; a breakdown had been avoided in these instances only because the parts were lightly loaded and had ample clearance.

W. E. WARNER.

Shefford, Bedfordshire, England.

New Equipment

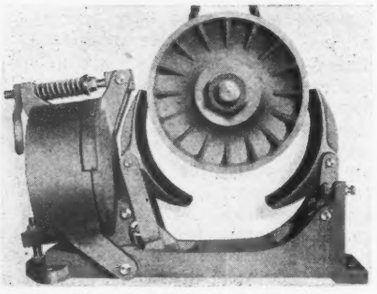
for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Electric Shoe Brake

A NEW shoe brake, announced by the Electric Controller and Mfg. Co., 2700 East 79th St., Cleveland, Ohio, is designed to meet the demand for a shoe brake giving longer life of shoe linings and permitting removal of the motor armature with brake wheel in place without the necessity of taking the brake apart or disturbing any of its adjustments.

The E. C. & M. Type WB brake is claimed to be radically different from any other shoe brake design in that no levers or rods pass over the top of the brake wheel. The brake shoe arms are



Electric Controller and Mfg. Co. Type WB Brake.

caused to operate in opposite directions by means of a simple lever movement having the connecting link within the base below the wheel. Steel castings and oversized bearing pins are furnished to assure smooth operation of the brake.

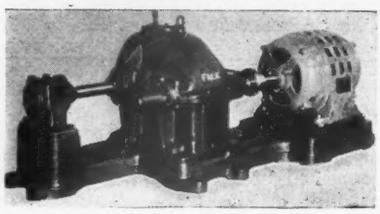
The brake shoe linings are asbestos interwoven with wire and molded to shape under heavy pressure. The linings are ½ in. thick on the smallest size brake and ¾ in. thick on the larger size.

Speed Reducers

A NEW line of speed reducers has recently been put on the market by the Falk Corporation, Milwaukee, Wis. These units feature the Falk continuous tooth and all-steel herringbone gears.

A special design of housing eliminates any internal ribs, projections or complicated cores. In this way lubrication has been simplified and, it is claimed, all possibility of dirt or core sand working into the gears is definitely removed. Added features are the airplane-type, steel-backed, babbitt-lined bearings that are capable of carrying heavier loads and an improved, automatic, continuous-lubrication system.

This line of reducers covers a certain number of standard reduction ratios,



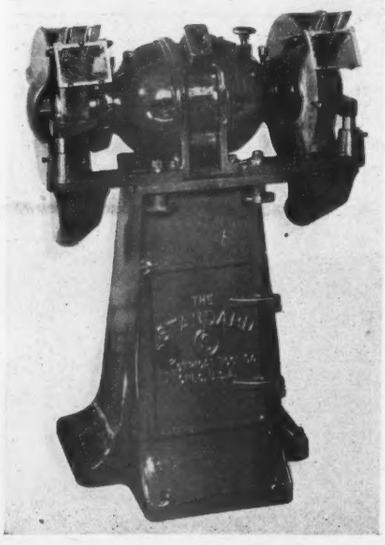
Falk Double Reduction Unit No. 7D

and standard motor beds have been adopted for them. The reducers are made in three types—single reduction for ratios up to 9:1, double reduction for ratios up to 70:1, and triple reduction for ratios up to 300:1.

Ball-Bearing Grinders

REDESIGNING of their complete line of electric grinding, polishing, and buffing machines has been announced by the Standard Electrical Tool Co., Cincinnati, Ohio. These units all have built-in motor and ball bearings. The accompanying illustration shows the new ball-bearing, pedestal-type grinder which is manufactured in two sizes of 3- and 5-hp. rated capacity. The 40-deg. motors and push-button control used in these grinders are of General Electric manufacture. The armature shafts are made of 3½ per cent nickel steel.

The SKF bearings are encased in dust-proof chambers. The emery wheel guards are of the hinge door type with exhaust connections. A spark breaker



Standard Electrical Tool Ball-Bearing Pedestal-Type Grinder.

and a polished, wire-glass eye shield are fitted on these guards.

The 3-hp. grinder carries emery wheels 12 in. x 2 in. or 14 in. x 2 in. and weighs 704 lb. The 5-hp. grinder carries wheels 18 in. x 3 in. and 20 in. x 3 in. and weighs 1,190 lb.

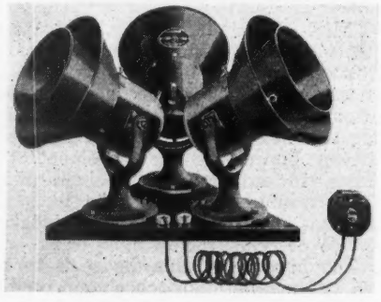
Motor-Driven Siren

MARKETING of the Triple-A siren designed for use as a fire alarm or as a signal for starting and stopping work is announced by the Federal Electric Co., 8700 S. State St., Chicago, Ill.

As the name indicates, this siren consists of three sirens mounted on a triangular base. These sirens are connected in parallel and are controlled from one push button switch, about 1 hp. being needed to operated them.

The tone of each siren is different and under normal conditions it is claimed that the unit has a sound radius of ⅝ to ½ mile in every direction.

The motor-housings and stator and rotor frames are die-cast aluminum.



Federal Electric Co. Triple-A Siren.

The horns and weather housings over the motor cases are seamless, deep-spun aluminum, the units being entirely inclosed.

The Triple-A siren is finished in red Duco and weighs about 40 lb.

Armored Cap Plugs

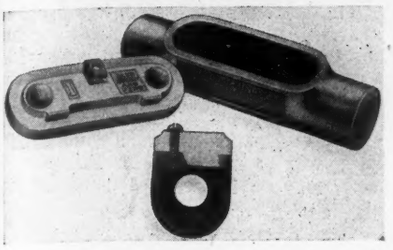
A NEW line of armored attachment plugs known as the RS and SS types has just been introduced to the trade by the Arrow Electric Co., Hartford, Conn. One of the features of these plugs is the fact that the composition cap is covered with a ribbed steel shell to protect it from damage due to blows or hard usage.

The SS plug cap differs from the RS type in that it is provided with a cord-gripping feature for protecting the cord.

Conduit Fittings

ANNOUNCEMENT of a new line of Obround condulets which, it is claimed, incorporate a new method of fastening covers and wiring devices to a condulet by means of the Wedge-Nut fastener, has been made by the Crouse-Hinds Co., Syracuse, N. Y. A few turns of the screw driver is all that is needed to secure the cover or wiring device to the condulet.

With this new form of construction



Obround Condulets Made by the Crouse-Hinds Co.

there are no screws projecting inwardly to injure the conductors, and because of the unobstructed cover opening they may be easily pulled through. The unobstructed cover opening and large wiring chamber also facilitate the splicing and taping of wires.

Another feature is that even in out-of-the-way places the covers and wiring devices may be conveniently installed as they can be turned so as to bring the fastening screws into an accessible position. These condulets are made in many different types for various uses.

Three-Wire System Switches

TWO-POLE switches with a solid neutral block for use on three-wire grounded systems have just been developed by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., in sizes ranging from 30- to 600-amp. rating. This type of switch is designed to utilize the advantages of reduced size made possible by using a solid neutral without the third switch blade, the size being reduced to that of a standard two-wire switch.

The 30-amp. size switch is of the OO type, the 60-, 100- and 200-amp. sizes are of the WK-62 type, and the 400- and 600-amp. sizes are of the WK-60 type. All the types up to 200 amp. rating may be supplied with a removable end adapted to a meter trip when it is desired to mount the meter in conjunction with the switch.

Slot Cleaning Outfit

MARKETING of a new slot cleaning device, which is shown in the illustration, has been announced by The Martindale Electric Co., 1260 West 4th St., Cleveland, Ohio.

This outfit comprises a ¼-hp., 1,750 r.p.m., Westinghouse motor, a 4-ft. flexible shaft, a ball-bearing handpiece and

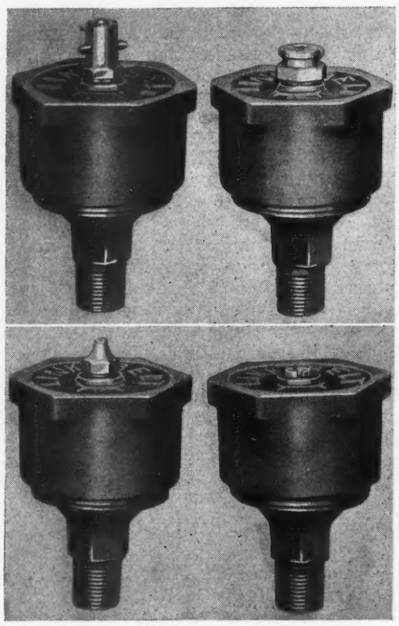
Martindale Slot Cleaning Outfit.

a disk holder. The grinding disks are thin and flexible and range from 4 to 8 in. in diameter. They are ordinarily used in pairs, placed back to back, so that a grinding surface is available on both sides. A ⅛-in. thick fibre stiffener may be placed between the disks to give additional stiffness.

It is stated that this outfit will quickly remove all old insulation and burrs from slots, as well as bad burns that sometimes result from a grounded coil, in which case the copper and iron are fused together. It is also recommended for removing old solder from riser necks.

Compression Grease Cup With Alemite Fitting

PRODUCTION and distribution of the Hex-Top malleable-iron, compression grease cup provided with various types of Alemite and Alemite-Zerk fittings, as shown in the accompanying



Link-Belt Hex-Top Compression Grease Cup With Alemite Fittings.

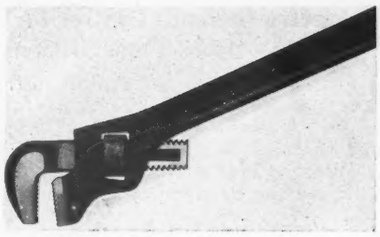
illustration, has been announced by the Link-Belt Co., 300 W. Pershing Road, Chicago, Ill.

The Hex-Top or six-sided head offers a ready grip for the hand or wrench, if necessary. When it is desired to refill, the cap is unscrewed until almost off and the grease applied through the Alemite or Zerk fitting. In this way it is not necessary to open the cup and so expose the grease to dusty air.

It is stated that this unit combines the advantages of both the compression grease cup with its reservoir of lubricant and the easy filling features of the grease gun.

Pipe Wrench

ANNOUNCEMENT is made by the Lawson Mfg. Co., Cleveland, Ohio, of an all-drop-forged-steel, hardened and tempered pipe wrench which is



Lawson Pipe Wrench with Angle Handle.

shown in the illustration. It contains only five parts.

As will be noted, one of the principle features of this wrench is the angle at which the handle is placed with respect to the jaws. This makes it possible to give one-eighth of a turn to a pipe lying parallel with a floor, wall or ceiling, where it would be difficult to use a straight-handled wrench. It is also said to be unusually easy to use in tight corners or among other pipes or obstructions, and that the design makes it possible to remove the wrench from a pipe by lifting it straight off.

Trickle Battery Chargers

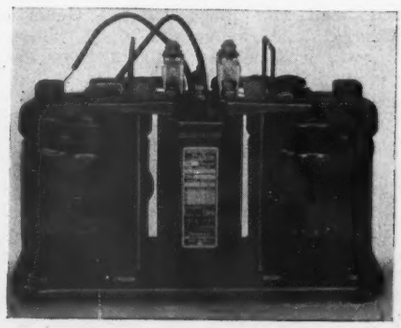
TWO heavy-duty Balkite trickle chargers for industrial use, Types RA and RB, have recently been placed on the market by the Fansteel Products Co., North Chicago, Ill. These two units are used where there is a demand for a continuous charger to trickle charge or float small-capacity, low-voltage storage batteries for fire alarm, signal, clock, recorder, telegraph and telephone systems, switch-operating batteries, or others where the average current drain will not exceed ¾ amp.

These units consist of an electrolytic rectifier, transformer, and resistance unit, compactly assembled for shelf mounting. The cell contains a tantalum (Balkite) and a lead electrode immersed in sulphuric acid electrolyte.

The resistance unit, in connection with the transformer taps, gives full control of the charging rate from 0 to a maximum of ¾ amp.

The Type RA single rectifier cell unit is used to charge from 1 to 6 cells, and the Type RB with two rectifier cells, as shown in the accompanying illustration, is used to charge from 7 to 12 cells. These units are available for 110- or 220-volt service and will operate on 25- to 140-cycle circuits.

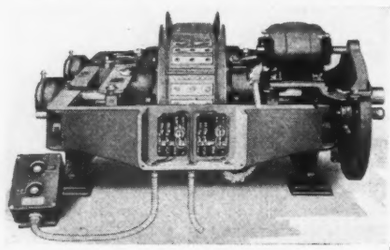
Type RB, Heavy-Duty Balkite Trickle Charger.



Electric Remote Control for Variable-Speed Transmission

RECENT addition of a push-button-operated, electrical remote control to its standard variable-speed transmission unit has been announced by the Reeves Pulley Co., Columbus, Ind. The control consists of a fractional-horsepower, reversible motor mounted on a bracket above the shifting screw of the transmission as shown in the illustration, and connected to the screw by a single reduction of spur gears. This motor is started in either direction by one or more push-button stations operating through a magnetic switch of special design.

Because of the small amount of power consumed when shifting the transmission, it is generally possible to connect the actuating motor to a standard lighting circuit for Reeves transmissions up to and including the No. 7 size. In case the operator should hold the push-button beyond the "slow" or "fast" limits of speed, a patented safety clutch prevents jamming of the



Reeves Push-Button-Operated Electrical Remote Control for Variable-Speed Transmission.

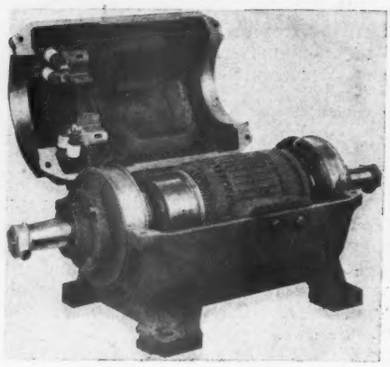
motor or transmission. The motor runs only when the "fast" or the "slow" button is depressed. Hence the speed of the transmission can be controlled within small limits.

This electrical remote control is said to be of particular value in connection with machines of considerable length, such as corrugating machines, traveling bread ovens, material handling conveyors, and so on, where it is inconvenient for the operator to leave the machine to adjust the speed transmission by hand. A tachometer may be located at any or all push-buttons so that the operator may know at all times the exact speed of the machine.

Steel Mill Motor

A NEW line of steel mill motors, to be known as the MD-400 series, has been announced by the General Electric Co., Schenectady, N. Y. These motors, it is claimed, have been designed in collaboration with the Standards Committee of the Association of Iron & Steel Electrical Engineers and fully meet the specifications of that body. The motors are of the roller-bearing type, but sleeve bearings can be supplied at the option of the purchaser.

The new line involves improved mechanical construction, more efficient use of materials and a refinement of details, as compared with the superseded line of MD-100 motors. Parts are more accessible and, at the same time, are better protected. Heat-resisting insulation (mica and asbestos) conforming to A.I.E.E. class B insulation specifications is employed in these motors, which are said to have the ability to commutate high overloads. They have also been designed to permit exceedingly rapid acceleration and frequent reversals.

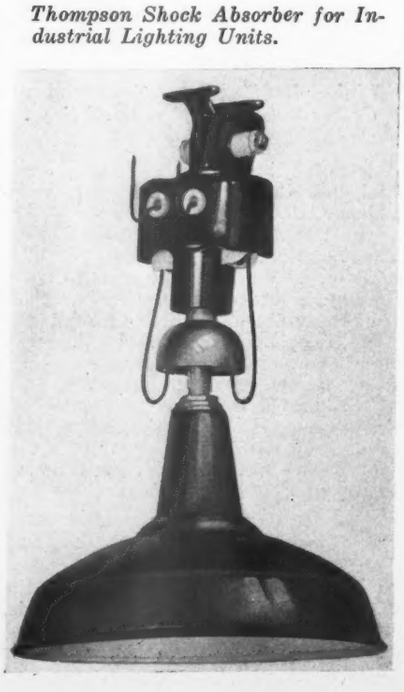


General Electric MD-400 Series Steel Mill Motor.

Lamp Shock Absorber

ANNOUNCEMENT of a shock absorber for industrial lamps has been made by the Thompson Electric Co., 1438 West Ninth St., Cleveland, Ohio. This shock absorber consists principally of a spring, which is designed to accommodate lamps of various weights, a canopy, a grid-plate and a stem, the latter three parts being malleable-iron castings. No screws or bolts are used in this device and all parts except the spring, are galvanized. The canopy is weatherproof and has a 1-in. standard thread at the top. The construction of the grid plate is said to be such that no matter how much it may be tilted by the swaying of the lamp, it will not drop out.

Thompson Shock Absorber for Industrial Lighting Units.



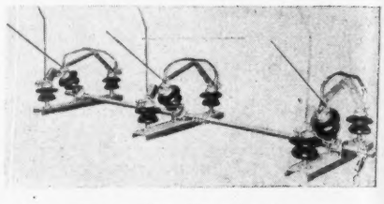
The bottom of the stem has a standard ¼-in. pipe thread for screwing into the top of the reflector, and is provided with ribs to prevent it from rotating in the grid-plate.

This resilient support for a lamp may be assembled between a Thompson hanger and bracket, or it may be screwed directly into a 1-in. outlet box or fitting.

Air-Break Disconnecting Switch

MARKETING of new gang-operated, air-break disconnecting switches designed for outdoor service has been announced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. These switches may be operated as single-, double- or three-pole units and are available for voltages of 7,500, 15,000, 25,000, 37,000, 50,000, and 73,000 and in capacities of 400 and 600 amp. A 200-amp. rating is also available for 7,500 and 15,000 volts.

The contact fingers on these switches are of the self-closing type and have



New Type RW Westinghouse Air-Break Disconnecting Switch.

ample contact surface. Arcing horns are furnished with all upright-mounted switches, but if not required may be discarded. These switches are also furnished for inverted and vertical base mountings. The operating mechanism is of the double-toggle type, with arrangement for padlocking in both positions.

Dereeler For Armature Winding Machines

MANUFACTURE of the new Chapman Compensating Tensionless Dereeler has been announced by the P. E. Chapman Electrical Works, N.E. Corner Tenth and Walnut Streets, St. Louis, Mo. The Dereeler is an auxiliary piece of apparatus for use in connection with any winding machine.

According to the manufacturer, the difficulty of taking the wire off the spool has been overcome by supplying a false head with a highly polished rim which fits the spool, preventing the wire from catching on any irregularities in the spool head. The false head is connected to the winding lathe, electrically or mechanically, so that starting and stopping the Dereeler with the lathe prevents over-feeding. It is stated that no objectionable twist is imparted to the wire when it is taken off over the spool head, and when winding wires having a single thread cover, the Dereeler compensates for the inherent twist, caused by the elasticity of the thread cover, permitting the wire to lay straight.

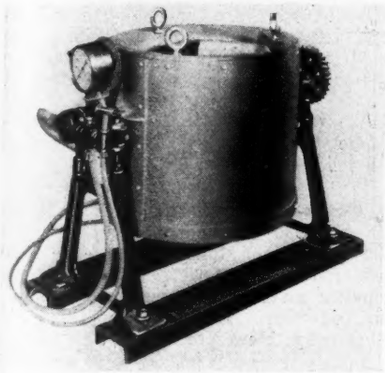
It is also claimed that whipping ac-

tion has been overcome and friction kept down by passing the wire through a damping tube which is carefully proportioned and set. In addition, there is little or no tension at any speed, allowing a sufficient margin for the drag of guiding devices and the operator's fingers, without stretching or injury to delicate coverings.

Babbitt Melting Pot

ANNOUNCEMENT is made by the Harold E. Trent Co., 439 North 12th St., Philadelphia, Pa., of a 750-lb. electrically-heated babbitt melting pot, with pouring spout and tilting mechanism, complete with automatic temperature control, as shown in the accompanying illustration.

These melting pots have, it is stated, a special cast-iron crucible, steel case, and heavy insulation. The special feature of these tilting-type pots is the



Babbitt Melting Pot Made by Harold E. Trent Co.

application of the temperature control, which is so placed as to be effective regardless of the position of the pot.

The constant use of the temperature control is of importance during the whole operation of melting and pouring bearings, so as to insure correct heating of the babbitt right up to the time it is poured.

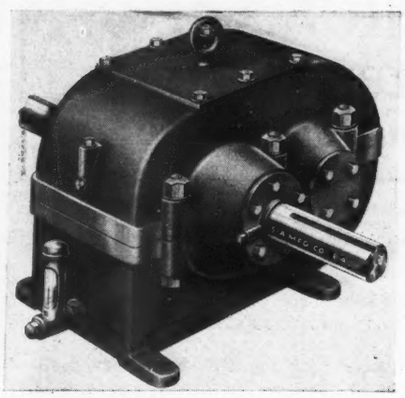
The tilting mechanism is operated by means of a handwheel. Special attention has been given to the construction of the worm gear drive, which makes the pot easy to tilt. These pots are arranged for operation on single-, two- or three-phase circuits.

Speed Reduction Unit

ANNOUNCEMENT is made by the Stephens-Adamson Mfg. Co., Aurora, Ill., of the introduction of an advanced type of speed reducer unit which is being marketed under the trade name of Speeducer.

This unit, which employs spur gears, is said to embody a number of unusual features of design. The gears and shafts are mounted in a rigid, oil-tight case, which insures the maintenance of proper alignment. The gears operate in a bath of oil, thus providing positive and ample lubrication.

Speeducer units are available in standard sizes for ratios up to 2000: 1, in capacities which range from 1 to



Stephens-Adamson Speeducer.

300 hp. For a given reduction ratio it is claimed to require less space than the ordinary open gear train.

Outdoor Substation

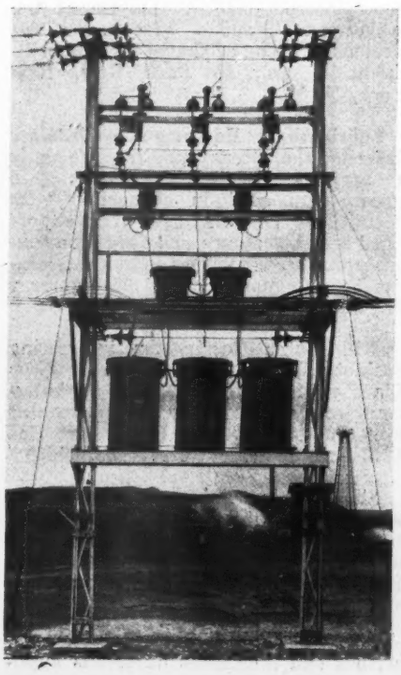
STANDARDIZED outdoor substations, particularly adapted for use in the oil fields and in other industrial applications where changes in the location of equipment may be necessary, have been made available by the Delta-Star Electric Co., 2,400 Block, Fulton St., Chicago, Ill.

These standardized substations can be quickly erected and easily moved when the load shifts, and it is claimed that they are provided with all the protective equipment of larger stations.

The unit shown in the illustration has been designed for 13,200/440-volt operation, taking care of three 50-kva. transformers. It is equipped with 27,000-volt insulators, insuring a high factor of safety.

The maximum height is 25 ft., but switching and reading of meters can be done from the ground. If in the future it is found desirable to use a ring system, a three-pole sectionalizing switch can be mounted on each pole of the steel structure.

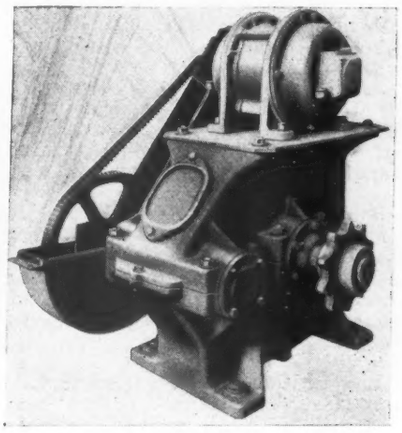
Delta-Star Outdoor Substation.



Speed Reducer Units with Silent Chain Drives

MANUFACTURE of two new types of speed reducers has been announced by H. W. Caldwell & Son Co., (Link-Belt Co. owner), Western Ave. at 17th and 18th Sts., Chicago, Ill.

The Caldwell speed reducer is a self-contained unit which combines two separate drives: a Link-Belt silent-chain drive between the motor and the high-speed shaft of the speed reducer which, in turn, gives a second reduction through a cut spur-gear drive to the low-speed shaft. The different variations in the low-speed shaft are ob-



Type A Caldwell Speed Reducer.

tained by the use of different sprocket ratios in the silent-chain drive. The reduction unit is made in two types; Type A, shown in the illustration, is designed for elevator and conveyor drives and for general industrial applications. Type B is for direct connection to screw conveyors. These units are made in sizes to give reduction ratios from 7:1 to 40:1 in Type A and up to 30:1 in Type B. Speed ratios may be changed at any time by substituting a different size of motor pinion or silent chain sprocket.

Both types of units are designed to mount the motor on top of the gear-reduction case.

Timken tapered roller bearings carried in cartridge mountings support the oversized shafts in the housing. Automatic lubrication of the cut spur gears and bearings is obtained from a large oil reservoir in the base of the housing. The chain is completely enclosed in an oil retaining case.

Type A unit is made for use with 5-, 7½-, 10-, and 15-hp. motors and Type B unit for use with motors of 3-, 5-, 7½-, 10-, 15- and 20-hp. The standard reductions listed in Book 630, which describes and prices this unit, may be obtained from the standard sizes of chains and sprockets (except for the 20-hp. unit) that are carried in stock in the various Link-Belt branches.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Distribution Specialties — A folder describes the line of G&W 100 per cent watershed capnut terminals in eight sizes and three styles, rated from 4,500 to 75,000 volts.—G&W Electric Specialty Co., 7780 Dante Ave., Chicago, Ill.

Scientific Instruments — Catalog 2000 contains 72 pages of information on thermometers, barometers and various other scientific instruments of American and English manufacture, with illustrations of these.—Taylor Instrument Companies, Rochester, N. Y.

Ball Bearings—Leaflet 25 illustrates the construction and application of ball bearings of the types used in electric motors.—The New Departure Manufacturing Co., Bristol, Conn.

Babbitt Metal—A 20-page booklet contains much useful information on the characteristics and uses of babbitt, and includes a table that gives the characteristics of different brands of babbitt.—Hoyt Metal Co., Boatmen's Bank Bldg., St. Louis, Mo.

Electric Furnaces—An electric furnace that is designed for the heat treatment of small ferrous and nonferrous parts is described in Bulletin 276.—W. S. Rockwell Co., 50 Church St., New York, N. Y.

Roller Chains—Various applications of Diamond Roller Chains are described and illustrated in Booklet 101.—Diamond Chain & Manufacturing Co., Indianapolis, Ind.

Conveyors—Various applications of the Cleveland Tram-Rail Systems are illustrated and explained in several leaflets.—Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Fans and Blowers—Bulletin 8001 contains 80 pages of descriptions and illustrations of fan and blower applications, with tables and diagrams for determining the proper size of fan or blower to be used.—American Blower Co., Detroit, Mich.

Portable Piling Machine—An 8-page booklet illustrates and describes a number of the applications of Brown Standard portable pilers and loaders.—Standard Conveyor Co., North St. Paul, Minn.

Painting Equipment—Bulletin 36-A describes the use of the Binks spray painting equipment for industrial maintenance.—Binks Spray Equipment Co., 3114-26 Carroll Ave., Chicago, Ill.

Insulated Electric Wires and Cables —A 71-page booklet gives the description, specifications, and all dimensions and ratings of the various types of bare and insulated copper wire and cable manufactured by this company. In addition, about 30 pages are devoted to engineering information and data, both in descriptive and tabular form.—Rome Wire Co., Rome, N. Y.

Limit Stops—Bulletin No. 1037 describes the Type B limit stops for use with a.c. and d.c. motors on cranes and other motor-driven machines that must be stopped automatically at certain points.—The Electric Controller & Mfg. Co., 2700 E. 79th St., Cleveland, Ohio.

Portable Electric Tools — A small circular illustrates and describes the line of Standard ball-bearing and air-cooled, high-power portable electric drills and grinders.—Standard Electrical Tool Co., 1936-46 West Eighth St., Cincinnati, Ohio.

Meters—Bulletin 74 covers the line of D-5 mercury-type watt-hour meters, containing detailed descriptions of the construction and operation, and other data regarding this equipment.—Sangamo Electric Co., Springfield, Ill.

Oil Purifier—A four-page circular describes the equipment used in the Hydroil continuous purification process by means of a bowl-type centrifugal separator. — Hydroil Sales Corporation, Lebanon, Ind.

Tachometer—Bulletin 225 describes the construction and operation and gives instructions for the use of the pocket-size Standco tachometer for measuring r.p.m. of shafts.—Herman H. Sticht & Co., 15 Park Row, New York, N. Y.

Lubricating Equipment — Circulars describe the Greas-Om-Eter, which is a spring-pressure, continuous-feed grease cup used in connection with Alemite or Zerk fittings. The cup is filled under pressure and feeds continuously due to the spring action.—Greas-Om-Eter Corporation, 460 Montgomery St., San Francisco, Calif.

Mill Motor Gossip—An interesting booklet that describes the various Clark products by means of an imaginary conversation between the various mill motors.—Clark Controller Co., 1146 East 152nd St., Cleveland, Ohio.

Short-Center Drive—A twelve-page booklet illustrates a number of applications of Pulmax short-center belt drives under unusual operating conditions.—Bird Machine Co., Pulmax Drive Division, South Walpole, Mass.

Tramrail—A 65-page catalog describes and illustrates numerous applications of the Atlas Duo-Rail system of mechanical conveying. This is an overhead tramrail system in which the carrier is supported on a double rail.—The Atlas-Chicago Co., Division of Chicago Electric Co., 740-744 West Van Buren St., Chicago, Ill.

Insulation—An announcement states that Mitchell-Rand Manufacturing Co. is now producing its line of tapes, webbings and sleevings in its own factory under its trade mark of Shield Brand. —Mitchell-Rand Manufacturing Co., 18 Vesey St., New York, N. Y.

Gravity Conveyors — A 12-page booklet describes a line of Standard gravity conveyor rolls, with particular attention to the varying types of roller bearings and their protection for the different industries in which these conveyors are used.—Standard Conveyor Co., North St. Paul, Minn.

Autovalve Arresters—Two new leaflets, L20013-H and L20149-C, have just been issued, describing the application, operation and other characteristics of Autovalve lightning arresters, Types LV and SV respectively.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

Relays—Supplement No. 1 to Bulletin No. 550 covers the new Type FR line of relays. These relays are used principally in connection with contact-making instruments, meters, and similar devices. Roller-Smith Co., 233 Broadway, New York, N. Y.

Fire Extinguishers—The uses of carbonic acid gas in fighting fires are strikingly described and illustrated in a folder covering the Fyre-Freez extinguisher.—General Carbonic Co., 17 W. 46th St., New York, N. Y.

Electric Hoists—The Universal Ball Bearing Electric Hoist is the title of a folder just issued by this company. It contains a complete description, a table of weight capacities, and illustrations of this hoist.—Louis E. Emerman & Co., 1761 Elston Ave., Chicago, Ill.

Electric Rivet Heaters—Catalog No. 26 describes and illustrates the Calorac line of electric rivet heaters.—Calorac Electric Corp., 52 Vanderbilt Ave., New York, N. Y.

Condulets—Catalog No. 2,100 describes the new Obround condulets with wedge-nut fastener. This 31-page publication contains illustrations of the numerous types of condulets with tables of sizes and prices.—Crouse-Hinds Co., Syracuse, N. Y.

Lighting Units—A 16-page illustrated booklet, No. 500, describes the Cooper-Hewitt, mercury vapor system of industrial plant lighting. Factors that must be taken into consideration in shop and room lighting are discussed at some length and tables are given showing the intensities produced by the lamps at various heights and distances. — Cooper-Hewitt Electric Co., Hoboken, N. J.